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(54) **A method for purifying combustion exhaust gas**

Verfahren zur Reinigung von Verbrennungsabgasen

Procédé pour la purification de gaz de combustion

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a process for purifying combustion exhaust gas and a device used in the process. More specifically, the present invention relates to a process which is capable of effectively resolving HC, CO and NO_x components, as well as an NH₃ component, in the combustion exhaust gas such as the exhaust gas from internal combustion engines, boilers and furnaces, and a device suitable for performing that process (in this specification, the term NO_x means any nitrogen oxide such as NO, NO₂, N₂O and N₃O₄, further, the term "resolving" means removing components in the exhaust gas, for example, by converting the components to other components by chemical reactions).

2. Description of the related art

[0002] A process for resolving three pollutants in a combustion exhaust gas, i.e., a hydrocarbon component (HC), a carbon-monoxide component (CO), and nitrogen-oxide components (NO_x), simultaneously is disclosed in, for example, Japanese Unexamined Patent Publication No. 53-86917. In the process disclosed in the '917 publication, the exhaust gas from an internal combustion engine is fed to a three-way reducing and oxidizing catalyst at an air-fuel ratio lower than the stoichiometric air-fuel ratio (i.e., a rich air-fuel ratio) and, after it passes through the three-way reducing and oxidizing catalyst, secondary air is added to the exhaust gas so that the air-fuel ratio of the exhaust gas becomes higher than the stoichiometric air-fuel ratio (i.e., a lean air-fuel ratio). Then, the exhaust gas of the lean air-fuel ratio is fed to an oxidizing catalyst. Namely, in the process disclosed in '917 publication, the combustion exhaust gas from the engine is first fed to a three-way reducing and oxidizing catalyst in a reducing atmosphere, and after it passes through the three-way reducing and oxidizing catalyst, the atmosphere of the exhaust gas is changed to an oxidizing atmosphere. Then, this exhaust gas with an oxidizing atmosphere is fed to an oxidizing catalyst.

[0003] As is well known in the art, a three-way reducing and oxidizing catalyst is capable of simultaneously oxidizing HC and CO components and reducing NO_x components in the exhaust gas when the air-fuel ratio of the exhaust gas is in a narrow air-fuel ratio range around the stoichiometric air-fuel ratio. However, when the air-fuel ratio of the exhaust gas is on the lean air-fuel ratio side compared to the above air-fuel ratio range (i.e., in an oxidizing atmosphere), the ability of the three-way reducing and oxidizing catalyst for reducing NO_x components falls rapidly. Further, when the air-fuel ratio of the exhaust gas is on a rich side compared to the

above optimum range (i.e., in a reducing atmosphere), the ability of the three-way reducing and oxidizing catalyst for oxidizing HC and CO components falls rapidly. Therefore, when a three-way reducing and oxidizing catalyst is used for decomposing HC, CO and NO_x components at the same time, it is necessary to control the engine so that the engine is always operated at an air-fuel ratio in the narrow air-fuel ratio range around the stoichiometric air-fuel ratio. In the actual operation of the engine, it is very difficult to maintain the operating air-fuel ratio of the engine strictly in such a narrow range in all operating conditions, and in some cases, emission of these components increases when the air-fuel ratio of the exhaust gas deviates from the optimum air-fuel ratio range.

[0004] In order to solve this problem, the internal combustion engine is operated at an air-fuel ratio lower than the stoichiometric air-fuel ratio in the process disclosed in the '917 publication and the air-fuel ratio of the exhaust gas is maintained on a rich side compared to the stoichiometric air-fuel ratio regardless of the change in the operating conditions of the engine. This rich air-fuel ratio exhaust gas is fed to the three-way reducing and oxidizing catalyst. Since the ability of the three-way reducing and oxidizing catalyst for reducing NO_x components is high when the air-fuel ratio of the exhaust gas is rich, almost all of the NO_x components in the exhaust gas are reduced by the reducing and oxidizing catalyst. Further, a portion of HC, CO components in the exhaust gas are oxidized by the reducing and oxidizing catalyst. After it passes through the three-way reducing and oxidizing catalyst, secondary air is supplied to the exhaust gas to adjust the air-fuel ratio of the exhaust gas so that the air-fuel ratio of the exhaust gas becomes lean, and this lean air-fuel ratio exhaust gas is, then fed to the oxidizing catalyst. Therefore, the portions of HC, CO components in the exhaust gas which are not oxidized by the three-way reducing and oxidizing catalyst are oxidized by the oxidizing catalyst in an oxidizing atmosphere.

[0005] According to the process in the '917 publication, NO_x components and part of HC, CO components are resolved by contacting the exhaust gas from the engine with three-way reducing and oxidizing catalyst in a reducing atmosphere, and the remaining portion of the HC, CO components are resolved by contacting the exhaust gas in an oxidizing atmosphere with the oxidizing catalyst after it passes through the three-way reducing and oxidizing catalyst. Since the air-fuel ratio of the exhaust gas from the engine is adjusted so that the air-fuel ratio becomes rich (a reducing atmosphere), then lean (an oxidizing atmosphere) in the process in '917 publication, i.e., it is not required to maintain the air-fuel ratio of the exhaust gas in the narrow optimum range, HC, CO and NO_x components in the exhaust gas can be resolved at high efficiency regardless of the operating condition of the engine.

[0006] However, one problem arises when the proc-

ess in the '917 publication is used for resolving HC, CO and NO_x components. The three-way reducing and oxidizing catalyst, though it has a high ability for reducing NO_x components in a reducing atmosphere, also converts a portion of NO_x components in the exhaust gas to NH₃ component (ammonia) in a reducing atmosphere. In the process in the '917 publication, since the rich air-fuel ratio exhaust gas is fed to the three-way reducing and oxidizing catalyst, the exhaust gas flows out from the three-way reducing and oxidizing catalyst contains a small amount of NH₃. This NH₃ in the exhaust gas is oxidized and again produces NO_x when the exhaust gas is fed to the oxidizing catalyst in an oxidizing atmosphere. Therefore, when the process in the '917 publication is used, it is difficult to decompose NO_x components in the exhaust gas completely, since NO_x components are produced by the oxidizing catalyst.

[0007] US-A-3,599,427 discloses a process for decomposing hydrocarbons and NO_x from an exhaust stream of internal combustion engines. In this process, NH₃ is purposively and externally added to a partially purified exhaust gas emerging from a first catalyst for the removal of hydrocarbons and carbon monoxide. Before entering into a second catalyst for removing NO_x, the exhaust gas is cooled and supplemented with NH₃.

SUMMARY OF THE INVENTION

[0008] In view of the problems in the related art, the object of the present invention is to provide a process and a device for purifying a combustion exhaust gas which is capable of decomposing substantially all of the HC, CO, and NO_x components as well as a NH₃ component in the exhaust gas while preventing NO_x from being produced by the oxidation of NH₃ contained in the exhaust gas.

[0009] The above object is achieved by a process for decomposing an NH₃ component in a combustion exhaust gas by contacting a combustion exhaust gas containing an NH₃ component in an oxidizing atmosphere at a temperature within a predetermined range with an NH₃ decomposing catalyst which decomposes the NH₃ component in an exhaust gas in an oxidizing atmosphere without substantially producing NO_x components in said oxidizing atmosphere when the temperature of the catalyst is in said predetermined temperature range, wherein said predetermined temperature range is defined so that at catalyst temperatures higher than said predetermined temperature range said NH₃ decomposing catalyst converts the NH₃ component in the exhaust gas in an oxidizing atmosphere to NO_x components and so that at catalyst temperatures lower than said predetermined temperature range said NH₃ decomposing catalyst allows the NH₃ component in the exhaust gas in an oxidizing atmosphere to pass through the catalyst.

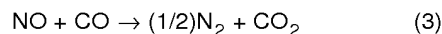
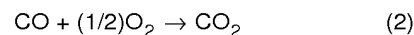
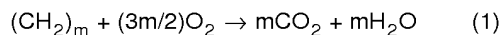
[0010] The NH₃ decomposing catalyst is capable of decomposing an NH₃ component in the exhaust gas in an oxidizing atmosphere when the temperature of the

catalyst is within the predetermined temperature range. Therefore, by feeding the exhaust gas containing a NH₃ component to the NH₃ decomposing catalyst in an oxidizing atmosphere and at a temperature within the predetermined range, substantially all of the NH₃ component in the exhaust gas is decomposed by the NH₃ decomposing catalyst without forming NO_x components.

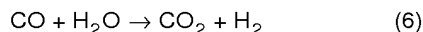
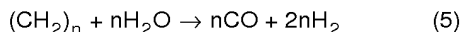
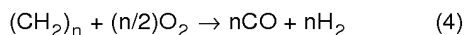
[0011] According to a preferred embodiment of the present invention, the process further comprises, contacting an exhaust gas of an internal combustion engine in a reducing atmosphere with an NH₃ synthesizing catalyst which converts NO_x components in the exhaust gas, in a reducing atmosphere, to an NH₃ component, and adjusting the conditions of the exhaust gas after it contacts the NH₃ synthesizing catalyst so that the exhaust gas is in an oxidizing atmosphere and within said predetermined temperature range.

[0012] In this embodiment of the invention, the exhaust gas from the internal combustion engine contacts the NH₃ synthesizing catalyst in a reducing atmosphere. Therefore, the NO_x component in the exhaust gas is converted to the NH₃ component. Further, after it has contacted the NH₃ synthesizing catalyst, the exhaust gas contacts the NH₃ decomposing catalyst in an oxidizing atmosphere and at the temperature within the predetermined temperature range. Thus, substantially all of the NH₃ component produced by the NH₃ synthesizing catalyst is resolved by the NH₃ decomposing catalyst, and the exhaust gas flowing out from the NH₃ decomposing catalyst is completely free from the NO_x and NH₃ components.

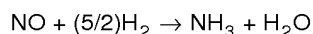
[0013] Further, the NH₃ synthesizing catalyst in the present invention is capable of decomposing most of pollutants in the exhaust gas when the exhaust gas is in a reducing atmosphere (i.e., when the oxygen concentration in the exhaust gas is low). For example, the pollutants such as HC, CO and NO in the exhaust gas are resolved by the NH₃ synthesizing catalyst by the following reactions when the exhaust gas is in a reducing atmosphere.



[0014] However, since the oxygen concentration is low when the exhaust gas is in a reducing atmosphere, a portion of CO and HC in the exhaust gas is not resolved by the above reactions (1) and (2), and a small amount of CO and HC are resolved by the following reactions.



[0015] When H_2 is formed by the reactions (4) through (6), NO in the exhaust gas reacts H_2 and a small amount of NH_3 is formed by the following reaction.



[0016] The speed of the reactions (4) through (6) are slow compared with the reactions (1) through (3), and when the oxygen concentration of the exhaust gas is low (for example, the excess air ratio λ of the exhaust gas is lower than 0.95), the reactions (4) through (6) are not likely to occur, and in this case CO and HC pass through the NH_3 synthesizing catalyst without being resolved. Therefore, to produce NH_3 component by the NH_3 synthesizing catalyst, the excess air ratio λ of the exhaust gas must be slightly lower than 1.0, for example, the value of λ must be $\lambda = 0.95$ to 1.0 and preferably between 0.98 and 1.0.

[0017] According to another aspect of the present invention, there is provided a device for decomposing an NH_3 component contained in the exhaust gas of an internal combustion engine comprising

an NH_3 decomposing catalyst disposed in an exhaust gas passage of an internal combustion engine, said NH_3 decomposing catalyst decomposes an NH_3 component in an exhaust gas flowing into the catalyst in an oxidizing atmosphere without substantially producing NO_x components in said oxidizing atmosphere when the temperature of the catalyst is in a predetermined temperature range, wherein said predetermined temperature range is defined so that at catalyst temperatures higher than said predetermined temperature range said NH_3 decomposing catalyst converts the NH_3 component in the exhaust gas in an oxidizing atmosphere to NO_x components and so that at catalyst temperatures lower than said predetermined temperature range said NH_3 decomposing catalyst allows the NH_3 component in the exhaust gas in an oxidizing atmosphere to pass through the catalyst; oxygen supply means for supplying oxygen to the exhaust gas flowing into said NH_3 decomposing catalyst so that the exhaust gas flowing into said NH_3 decomposing catalyst becomes oxidizing atmosphere; and temperature maintaining means for maintaining the

temperature of the exhaust gas flowing into said NH_3 decomposing catalyst within said predetermined temperature range regardless of a change in the temperature of the exhaust gas discharged from the internal combustion engine.

[0018] In this aspect of the invention, the oxygen supply means adjust the conditions of the exhaust gas so that the exhaust gas becomes an oxidizing atmosphere, and the temperature maintaining means maintains the temperature of the exhaust gas within the predetermined temperature range. Thus, an exhaust gas is fed to the NH_3 decomposing catalyst in an oxidizing atmosphere and at the temperature within the predetermined temperature, and the NH_3 component in the exhaust gas is resolved by the NH_3 decomposing catalyst.

[0019] According to a further embodiment of the invention, the device comprises a plurality of NH_3 decomposing catalysts disposed in the exhaust gas passage in series arrangement wherein each of the NH_3 decomposing catalysts decomposes an NH_3 component in the exhaust gas flowing into the catalyst in an oxidizing atmosphere without substantially producing NO_x components in said oxidizing atmosphere when the temperature of the catalyst is in said predetermined temperature range, said oxygen supply means supplying oxygen selectively to the exhaust gas flowing into the respective NH_3 decomposing catalysts, said temperature detecting means detecting the temperature of the respective NH_3 decomposing catalysts, and selecting means for controlling the oxygen supply means in such a manner that the oxygen supply means supplies oxygen to the exhaust gas flowing into the NH_3 decomposing catalyst(s) whose temperature is within the predetermined temperature range.

[0020] In this embodiment of the invention, more than one NH_3 decomposing catalysts are disposed on the exhaust gas passage of the engine in a series arrangement. Since the temperature of the exhaust gas from the engine becomes low as the exhaust gas flows down the exhaust gas passage due to the heat dissipation through the wall of the exhaust gas passage, the temperatures of the exhaust gas flowing into the respective NH_3 decomposing catalyst are different from each other according to the location of the catalyst. Consequently, the temperature of the NH_3 decomposing catalysts are also different from each other. The selecting means selects the NH_3 decomposing catalyst, which has a temperature within the predetermined range, and controls the oxygen supply means so that oxygen is supplied to the NH_3 decomposing catalyst having temperature within the predetermined range. Therefore, the exhaust gas in an oxidizing atmosphere is supplied to the NH_3 decomposing catalyst at a temperature within the predetermined temperature range, and the NH_3 component in the exhaust gas is effectively decomposed by the NH_3 decomposing catalyst even if the temperature of the exhaust gas at the outlet of the engine changes due to a

change in the operating condition of the engine.

[0021] In a preferred embodiment of the inventive process, since NH_3 is added to the exhaust gas before the exhaust gas is fed to the NH_3 decomposing catalyst, the exhaust gas flowing into the NH_3 decomposing catalyst in oxidizing atmosphere and at the temperature within the predetermined temperature range contains NO_x and NH_3 , the NO_x components in the exhaust gas react with the NH_3 component on the NH_3 decomposing catalyst and are decomposed.

[0022] In a preferred embodiment of the inventive device, the internal combustion engine may be operated at a lean air-fuel ratio and the exhaust gas from the engine is in an oxidizing atmosphere. NH_3 is added to this exhaust gas before the exhaust gas flows into the NH_3 decomposing catalyst. Further, the temperature of the exhaust gas is maintained within the predetermined range. Therefore, the exhaust gas containing NO_x components and a NH_3 component is fed to the NH_3 decomposing catalyst in an oxidizing atmosphere and at the temperature within the predetermined temperature range, and the NO_x components in the exhaust gas reacts the NH_3 component at the NH_3 decomposing catalyst and resolved.

[0023] In a further preferred embodiment of the inventive device; more than one NH_3 decomposing catalysts are disposed on the exhaust gas passage of the engine. Since the temperature of the exhaust gas becomes lower as the exhaust gas flows down the exhaust gas passage, the temperatures of the respective NH_3 decomposing catalysts vary in accordance with the location of the NH_3 decomposing catalysts. Therefore, even when the temperature of the exhaust gas changes due to change in the operating condition of the engine, some of the NH_3 decomposing catalysts always stay in the predetermined temperature range. A selecting means controls the NH_3 supply means so that NH_3 is supplied to the exhaust gas flowing into the NH_3 decomposing catalysts which has a temperature within the predetermined range. Therefore, exhaust gas in an oxidizing atmosphere containing NH_3 and NO_x is fed to the NH_3 decomposing catalyst which has the temperature within the predetermined range. Consequently, the NO_x component in the exhaust gas reacts the NH_3 component at the NH_3 decomposing catalyst and decomposed.

[0024] According to a further preferred embodiment of the present invention, the device may be operated so that the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio in such a manner that the average operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio, the device additionally comprises an NH_3 synthesizing catalyst disposed in an exhaust gas passage of the engine, wherein the NH_3 synthesizing catalyst converts NO_x components in the exhaust gas discharged from the engine when the operating air-fuel ratio of the engine is lower than the stoichiometric air-fuel ratio to NH_3 and N_2 components, and an NH_3 decomposing catalyst disposed

on the exhaust gas passage downstream of the NH_3 synthesizing catalyst, wherein the NH_3 decomposing catalyst adsorbs the NH_3 component produced by the NH_3 synthesizing catalyst when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio and wherein the NH_3 decomposing catalyst reduces NO_x components in the exhaust gas discharged from the engine and pass through the NH_3 synthesizing catalyst when the operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio by reacting the NO_x components with the NH_3 component adsorbed in the NH_3 decomposing catalyst.

[0025] In this embodiment of the invention, the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio. When the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio (i.e., rich air-fuel ratio), the NO_x producing catalyst converts the NO_x components discharged from the engine to NH_3 and N_2 components. This NH_3 component is absorbed by the NH_3 decomposing catalyst disposed at downstream of the NH_3 synthesizing catalyst. Therefore, NH_3 component is not discharged to atmosphere. When the engine operating air-fuel ratio becomes higher than the stoichiometric air-fuel ratio (i.e., lean air-fuel ratio), the NO_x components discharged from the engine pass through the NH_3 synthesizing catalyst without being converted to NH_3 and N_2 component. However, the NO_x components pass through the NH_3 synthesizing catalyst is reduced at the NH_3 decomposing catalyst by reacting the NH_3 component absorbed by the NH_3 decomposing catalyst. Therefore, both the NO_x and NH_3 components are not discharged to atmosphere.

[0026] According to a further preferred embodiment of the present invention, the device may be operated so that, the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio in such a manner that the average operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio, the device additionally comprises an NH_3 synthesizing catalyst disposed in an exhaust gas passage of the engine, wherein the NH_3 synthesizing catalyst converts NO_x components in the exhaust gas discharged from the engine when the operating air-fuel ratio of the engine is lower than the stoichiometric air-fuel ratio to NH_3 and N_2 components, an NO_x absorbent disposed on the exhaust gas passage downstream of the NH_3 synthesizing catalyst, wherein the NO_x absorbent absorbs NO_x components in the exhaust gas discharged from the engine and pass through the NH_3 synthesizing catalyst when the operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio and releases the absorbed NO_x components when the engine operating air-fuel ratio becomes lower than the stoichiometric air-fuel ratio, and said NH_3 decomposing catalyst is disposed on the exhaust gas passage downstream of the NO_x absorbent, wherein, when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio, the NH_3 decomposing catalyst reduces the NO_x components re-

leased from the NO_x absorbent by reacting the NO_x components with the NH_3 component produced by the NH_3 synthesizing catalyst.

[0027] In this embodiment of the invention, the NO_x components discharged from the engine when the engine operating air-fuel ratio is higher than the stoichiometric air-fuel ratio are absorbed by the NO_x absorbent. Therefore, the NO_x components are not discharged to atmosphere when the engine operating air-fuel ratio is higher than the stoichiometric air-fuel ratio. When the engine operating air-fuel ratio becomes lower than the stoichiometric air-fuel ratio, the NO_x components absorbed by the NO_x absorbent are released from the NO_x absorbent. However, the NH_3 synthesizing catalyst converts the NO_x components discharged from the engine to NH_3 and N_2 components when the engine operating air-fuel ratio becomes lower than the stoichiometric air-fuel ratio. Therefore, the NO_x components released from the NO_x absorbent and the NH_3 component produced by the NH_3 synthesizing catalyst flows into the NH_3 decomposing catalyst at the same time. These NO_x and NH_3 components react each other and form N_2 and H_2O components. Thus, both the NO_x and NH_3 components are not discharged to atmosphere.

[0028] According to a further preferred embodiment of the present invention, the device may be operated so that the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio in such a manner that the average operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio, the device additionally comprising an NH_3 synthesizing catalyst disposed in an exhaust gas passage of the engine, wherein the NH_3 synthesizing catalyst converts NO_x components in the exhaust gas discharged from the engine when the operating air-fuel ratio of the engine is lower than the stoichiometric air-fuel ratio to NH_3 and N_2 components, said NH_3 decomposing catalyst is disposed on the exhaust gas passage downstream of the NH_3 synthesizing catalyst, wherein the NH_3 decomposing catalyst absorbs NO_x components in the exhaust gas discharged from the engine and pass through the NH_3 synthesizing catalyst when the operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio and wherein the NH_3 decomposing catalyst reduces the absorbed NO_x components by reacting the NO_x components with the NH_3 component produced by the NH_3 synthesizing catalyst when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio.

[0029] In this embodiment of the invention, the NH_3 decomposing catalyst is also capable of absorbing the NO_x components in the exhaust gas flowing into the NH_3 decomposing catalyst when the engine operating air-fuel ratio is higher than the stoichiometric air-fuel ratio. Thus, the NO_x components are not discharged to atmosphere when the engine operating air-fuel ratio is higher than the stoichiometric air-fuel ratio. When the engine operating air-fuel ratio becomes lower than the

stoichiometric air-fuel ratio, a NH_3 component is produced by the NH_3 synthesizing catalyst upstream of the NH_3 decomposing catalyst. However, this NH_3 component is oxidized at the NH_3 decomposing catalyst by reacting the NO_x components absorbed by the NH_3 decomposing catalyst. Therefore, both the NO_x and NH_3 components are not discharged to atmosphere when the engine operating air-fuel ratio becomes lower than the stoichiometric air-fuel ratio.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] The present invention will be better understood from the description, as set forth hereinafter with reference to the accompanying drawings in which:

Fig. 1 is a drawing schematically illustrating an embodiment of the present invention when applied to an automobile engine;

Fig. 2 is a drawing schematically illustrating another embodiment of the present invention;

Fig. 3 is a drawing schematically illustrating another embodiment of the present invention;

Fig. 4 is a drawing schematically illustrating another embodiment of the present invention;

Fig. 5 is a drawing schematically illustrating another embodiment of the present invention;

Fig. 6 is a drawing showing the change in the characteristics of an NH_3 decomposing catalyst in accordance with the change in the temperature; and
Fig. 7 is a drawing schematically illustrating another embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0031] In the embodiments explained hereinafter, NH_3 decomposing catalysts are used for decomposing NO_x and NH_3 from a combustion exhaust gas. Therefore, an NH_3 decomposing catalyst is explained before explaining the respective embodiments.

[0032] The NH_3 decomposing catalyst in the embodiments of the present invention uses, for example, a honeycomb type substrate made of cordierite, and an alumina layer which act as a carrier for the catalyst is coated on the cell surface of the honeycomb substrate. On this carrier, at least one substance selected from elements belong to the fourth period or the eighth group in the periodic table of elements, such as copper (Cu), chrome (Cr), vanadium (V), titanium (Ti), iron (Fe), nickel (Ni), cobalt (Co.), platinum (Pt), palladium (Pd), rhodium (Rh) and iridium (Ir) are carried as a catalyst.

[0033] The NH_3 decomposing catalyst is capable of converting all the NH_3 component in the exhaust gas flowing into the NH_3 decomposing catalyst to the N_2 component provided that the exhaust gas is in an oxidizing atmosphere and the temperature of the catalyst is within a specific temperature range as determined by the substance being used as the catalyst. Therefore,

when the exhaust gas is an oxidizing atmosphere containing a NH_3 component and flows through the NH_3 decomposing catalyst in this temperature range, the NH_3 component in the exhaust gas is almost completely decomposed, and the exhaust gas flows out from the NH_3 decomposing catalyst contains no NH_3 component. In the explanation below, this temperature range in which the NH_3 decomposing catalyst can decompose all the NH_3 component in the exhaust gas is called an optimum temperature range.

[0034] When the temperature of the NH_3 decomposing catalyst is higher than the optimum temperature range, the NH_3 component in the exhaust gas flowing into the NH_3 decomposing catalyst is oxidized by the NH_3 decomposing catalyst and NO_x components are produced.

[0035] Namely, when the temperature of the NH_3 decomposing catalyst is higher than the optimum temperature range, the oxidizing reaction of the NH_3 component, i.e., $4\text{NH}_3 + 7\text{O}_2 \rightarrow 4\text{NO}_2 + 6\text{H}_2\text{O}$, and/or $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$ become dominant on the NH_3 decomposing catalyst, and the amount of NO_x components (mainly NO and NO_2) in the exhaust gas flowing out from the NH_3 decomposing catalyst increases.

[0036] Further, when the temperature of the NH_3 decomposing catalyst is lower than the optimum temperature range, the oxidizing reaction of the NH_3 component becomes lower, and the amount of the NH_3 component in the exhaust gas flowing out from the NH_3 decomposing catalyst increases.

[0037] Fig. 6 schematically illustrates the change in the characteristics of the NH_3 decomposing catalyst in accordance with the change in the temperature. Fig. 6 shows the change in the concentration of the NH_3 and NO_x components in the exhaust gas flowing out from the NH_3 decomposing catalyst in accordance with the temperature of the NH_3 decomposing catalyst when the exhaust gas flowing into the NH_3 decomposing catalyst is in an oxidizing atmosphere and the concentration of NH_3 in the exhaust gas is maintained at a constant level. The vertical axis and the horizontal axis in Fig. 6 represent the concentration of the respective components in the exhaust gas and the temperature of the NH_3 decomposing catalyst, respectively. The solid line and the dotted line in Fig. 6 represent the concentrations of the NH_3 component and the NO_x components in the exhaust gas flowing out from the NH_3 decomposing catalyst.

[0038] As shown in Fig. 6, provided that the concentration of the NH_3 component in the exhaust gas flowing into the NH_3 decomposing catalyst is maintained at a constant level, the concentration of the NH_3 component in the outflow exhaust gas is substantially the same as the concentration of NH_3 in the inflow exhaust gas in the low temperature region (region I, in Fig. 6). In this temperature region, the concentration of the NO_x components in the outflow exhaust gas is substantially zero. This means that substantially all of the NH_3 component in the exhaust gas passes the NH_3 decomposing cata-

lyst without reaction when the temperature is low (region I in Fig. 6).

[0039] When the temperature becomes higher than the above low temperature region, the concentration of the NH_3 component in the outflow exhaust gas decreases as the temperature increases, while the concentration of the NO_x components is substantially the same (region II in Fig. 6). Namely, in this temperature region, the amount of NH_3 component in the exhaust gas which is converted to N_2 component increases as the temperature increases.

[0040] When the temperature further increases, as shown in region III in Fig. 6, the concentration of NH_3 component in the outflow exhaust gas further decreases and the concentration of both the NH_3 and NO_x components becomes substantially zero. Namely, in this temperature region (region III in Fig. 6), all of the NH_3 component in the exhaust gas flowing into the NH_3 decomposing catalyst is decomposed (i.e., converted to N_2 component) by NH_3 decomposing catalyst without forming NO_x components.

[0041] However, when the temperature becomes higher than this region, the concentration of the NO_x components in the outflow exhaust gas increases as the temperature increases (region IV in Fig. 6), and all of the NH_3 component in the exhaust gas is converted to NO_x components by the NH_3 decomposing catalyst in a high temperature region (region V in Fig. 6).

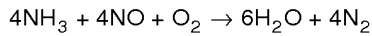
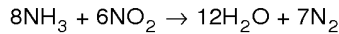
[0042] In this specification, the optimum temperature range of the NH_3 decomposing catalyst is defined as a temperature range in which all of the NH_3 component in the exhaust gas is converted to N_2 component without forming any NO_x component, i.e., such as the temperature range indicated by the temperature region III in Fig. 6.

[0043] The optimum temperature range of the NH_3 decomposing catalyst changes according the substance used as catalytic component, and generally starts at a relatively low temperature compared with, for example, the activating temperature of the three-way reducing and oxidizing catalyst. For example, when a substance such as platinum (Pt), rhodium (Rh), or palladium (Pd) is used, the optimum temperature range is approximately 100 to 400°C (preferably 100 to 300°C and most preferably 100 to 250°C in case of platinum (Pt), and preferably 150 to 400°C and most preferably 150°C to 300°C in case of rhodium (Rh) or palladium (Pd)). When a substance such as copper (Cu), chrome (Cr), or iron (For example) is used, the optimum temperature range is approximately 150 to 650°C (preferably, 150 to 500°C). Therefore, if the NH_3 decomposing catalyst is formed as a tandem compound type catalyst using both types of the catalytic component, i.e., if the catalytic components such as platinum (Pt) are carried on the downstream part of the substrate and the catalytic components such as chrome (Cr) are carried on the upstream part of the substrate, the optimum temperature range of the NH_3 decomposing catalyst can be widened

as a whole.

[0044] The reason why the NH_3 decomposing catalyst converts substantially all of the NH_3 component in the exhaust gas to the N_2 component without producing any NO_x components only in the specific temperature range is not clear at present. However, it is considered that this phenomenon is due to the following reason.

[0045] When the temperature of the NH_3 decomposing catalyst is in the optimum temperature range, the following denitrating reactions occur in the NH_3 decomposing catalyst, in addition to the above mentioned oxidizing reactions $4\text{NH}_3 + 7\text{O}_2 \rightarrow 4\text{NO}_2 + 6\text{H}_2\text{O}$ and/or $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$:



[0046] Due to these denitrating reactions, the NO_x components produced by the oxidizing reactions are immediately converted to the N_2 component. Namely, in the optimum temperature range, a portion of the NH_3 in the exhaust gas flowing into the NH_3 decomposing catalyst is converted to NO_x by the oxidizing reactions, and this NO_x immediately reacts the remaining NH_3 in the exhaust gas and is converted to N_2 by the denitrating reactions. By these sequential reactions, substantially all of the NH_3 in the exhaust gas is converted to N_2 when the temperature of the catalyst is within the optimum temperature range.

[0047] When the temperature of the NH_3 decomposing catalyst is above the optimum temperature range, the oxidizing reactions become dominant in the catalyst and the portions of NH_3 which is oxidized by the catalyst increases. Thus, the denitrating reactions hardly occur in the catalyst due to the shortage of NH_3 component in the exhaust gas, and the NO_x produced by the oxidizing reactions flows out from the NH_3 decomposing catalyst without being reduced by the denitrating reactions.

[0048] On the other hand, when the temperature of NH_3 decomposing catalyst is below the optimum temperature range, the oxidizing reactions hardly occur due to the low temperature. This causes the NH_3 in the exhaust gas passes through the NH_3 decomposing catalyst without being oxidized by the NO_x due to the shortage of the NO_x in the exhaust gas.

[0049] As explained above, the optimum temperature range of the NH_3 decomposing catalyst is a temperature range in which the oxidizing reactions of the NH_3 and the denitrating reactions of the NO_x balance each other in such a manner that the NO_x produced by the oxidation of the NH_3 immediately reacts with NH_3 in the exhaust gas without causing any surplus NO_x and NH_3 . Consequently, the optimum temperature range of the NH_3 decomposing catalyst is determined by the oxidizing ability

of the catalyst and its temperature dependency. Therefore, when the catalyst component having high oxidizing ability, such as platinum (Pt), is used, the optimum temperature range becomes lower than that when the catalyst component having relatively low oxidizing ability, such as chrome (Cr) is used.

[0050] As explained above, though the mechanism of the phenomenon is not completely clarified, the NH_3 decomposing catalyst actually converts all of the NH_3 in the exhaust gas in an oxidizing atmosphere when the temperature is within the optimum temperature range. Further, when the NH_3 decomposing catalyst is used in the optimum temperature range the following facts were found in connection with the above phenomenon:

(a) When the exhaust gas flowing into the NH_3 decomposing catalyst is in an oxidizing atmosphere, i.e., when the air-fuel ratio of the exhaust gas is lean compared to the stoichiometric air-fuel ratio, substantially all of the NH_3 in the exhaust gas is converted to N_2 without producing any NO_x . This occurs when the exhaust gas is in an oxidizing atmosphere (a lean air-fuel ratio), but regardless of the degree of leanness of air-fuel ratio of the exhaust gas. (In this specification, an air-fuel ratio of the exhaust gas at a certain point is defined by a ratio of the air and the fuel which are supplied to the combustion chambers or exhaust passages upstream of the point. Therefore, when no air or fuel is supplied in the exhaust passages upstream of the considered point, the air-fuel ratio of the exhaust gas at the point becomes the same as the air-fuel ratio of the air-fuel mixture supplied to the combustion chambers).

(b) When the exhaust gas flowing into the NH_3 decomposing catalyst contains NO_x in addition to NH_3 , all of the NO_x in the exhaust gas as well as the NH_3 is converted to N_2 , and the concentration of the NO_x components in the exhaust gas becomes zero. In this case, the ratio of the concentrations of the NO_x components and the NH_3 component is not necessarily stoichiometrical for the denitrating reactions (i.e., 4:3, or 1:1). It is only required that the exhaust gas contains an amount of NH_3 more than the amount required for reducing the NO_x (NO_2 and NO) in the exhaust gas. As explained above, since the surplus NH_3 in the exhaust gas is all converted to N_2 when the exhaust gas is in an oxidizing atmosphere, no surplus NH_3 is contained in the decomposing catalyst contains HC and CO components, all of the HC and CO components are oxidized by the NH_3 decomposing catalyst, provided that the air-fuel ratio of the exhaust gas is lean compared to the stoichiometric air-fuel ratio, and no HC and CO components are contained in the exhaust gas flowing out from the NH_3 decomposing catalyst.

[0051] However, when the exhaust gas flowing into the NH_3 decomposing catalyst contains both the NH_3

and NO_x , it was found that the temperature region IV in Fig. 6, i.e., the temperature region in which the concentration of NO_x components in the outflow exhaust gas increases as the temperature of the catalyst increases, moves to the lower temperature side compared to that when the exhaust gas flowing into the NH_3 decomposing catalyst contains only the NH_3 components. This is because, when the exhaust gas contains NO_x in addition to NH_3 , the NO_x in the inflow exhaust gas in addition to the NO_x produced by the oxidizing reaction of NH_3 must be reduced by the NH_3 in the exhaust gas. Consequently, the shortage of the NH_3 is apt to occur in the relatively low temperature region. Therefore, when the exhaust gas contains both the NH_3 and the NO_x , the optimum temperature range of the NH_3 decomposing catalyst becomes narrower.

[0052] In relation to above (b), a conventional denitrating catalyst, such as a vanadia-titania (V_2O_5 - TiO_2) type catalyst also has a capability for resolving NH_3 and NO_x in the exhaust gas under certain conditions. However, in case of the conventional denitrating catalyst, the amounts of NH_3 and NO_x components must be strictly stoichiometrical in order to react NH_3 with NO_x without causing any surplus NH_3 and NO_x . Namely, when both the NO_2 and NO are contained in the exhaust gas, the amount equal to the total of the moles of NO_2 in the exhaust gas multiplied by 3/4 and the moles of NO in the exhaust gas in order to react NH_3 and NO_x without causing any surplus NH_3 and NO_x . However, in case of the NH_3 decomposing catalyst in the embodiments of the present invention, if the amount of the NH_3 is more than the stoichiometrical compared to the amount of NO_x , and if the air-fuel ratio of the exhaust gas is lean, all of the NH_3 and NO_x are converted to N_2 without causing any surplus NH_3 and NO_x . This is an important difference between the NH_3 decomposing catalyst in the present invention and the conventional denitrating catalyst.

[0053] As explained in Fig. 6, though the NH_3 decomposing catalyst converts all of the NH_3 in the exhaust gas in the optimum temperature range, some NH_3 passes through region can be reduced. The NH_3 absorbed by the acidic inorganic substances are released when the temperature of the NH_3 decomposing catalyst becomes high, or when the concentration of NH_3 component in the exhaust gas becomes low. Therefore, the NH_3 absorbed by the acidic inorganic substance is converted to N_2 by the NH_3 decomposing catalyst when it is released from the acidic inorganic substance. When the temperature of the exhaust gas flowing into the NH_3 decomposing catalyst changes in a wide range, therefore, it is suitable to use these acidic inorganic substances to prevent the outflow of NH_3 in low temperature region.

[0054] Next, embodiments of the present invention which utilizes the NH_3 decomposing catalyst are explained.

[0055] Fig. 1 schematically illustrates an embodiment

of the present invention when applied to an internal combustion engine. In Fig. 1, reference numeral 1 represents an internal combustion engine, 2 represents an exhaust gas passage of the engine 1. On the exhaust gas passage, a three-way reducing and oxidizing catalyst 3, a muffler 5 and a NH_3 decomposing catalyst 7 are disposed, from the upstream end, in this order. Numeral 9 in Fig. 1 designates a secondary air supply unit which injects air into the exhaust gas passage at the portion between the muffler 5 and NH_3 decomposing catalyst 7.

[0056] The three-way reducing and oxidizing catalyst 3 is a known type which uses, for example, a honeycomb type substrate. On this substrate, an alumina layer which acts as a carrier of the catalytic components is applied. In this embodiment, catalytic components of precious metals such as platinum (Pt), palladium (Pd) and rhodium (Rh) and additives such as cerium (Ce) are attached to the alumina carrier. As is well known, the three-way reducing and oxidizing catalyst 3 can decompose HC, CO and NO_x components in the exhaust gas effectively when the air-fuel ratio of the exhaust gas is near the way reducing and oxidizing catalyst reduces substantially all of NO_x in the exhaust gas, but, in this case, a portion of NO_x in the exhaust gas is converted to NH_3 at the same time. Namely, the three-way reducing and oxidizing catalyst 3 can act as an NH_3 synthesizing catalyst when the air-fuel ratio of the exhaust gas flowing into the catalyst is rich compared to the stoichiometric air-fuel ratio.

[0057] The muffler 5 is a conventional type which lowers the sound pressure level by expanding the exhaust gas, and in this embodiment, also used for reducing the temperature of the exhaust gas by expanding it. Further, since the muffler 5 has a relatively large heat capacity, the change in the temperature of the exhaust gas at downstream of the muffler 5 can be kept small even when the temperature of the exhaust gas at upstream of the muffler 5 changes due to the change in the operating conditions of the engine 1 occurs.

[0058] As explained before, the NH_3 decomposing catalyst 7 is capable of resolving all of the NH_3 in the exhaust gas when the exhaust gas flowing into the catalyst 7 is in an oxidizing atmosphere and the temperature of the catalyst 7 is within the optimum temperature range. However, when the temperature of the catalyst becomes lower than the optimum temperature range, an outflow of NH_3 occurs. To prevent this outflow of NH_3 in the low temperature region, the acidic inorganic substance may be attached to the substrate of the NH_3 decomposing catalyst or the substrate itself may be formed by a porous material made of the acidic inorganic substance.

[0059] The secondary air supply unit 9 includes a pressurized air source 9a such as an air pump, nozzle 10 for injecting air into the exhaust gas passage upstream of the NH_3 decomposing catalyst 7 and a shut off valve 11 disposed on the piping connecting the air source 9a and the nozzle 10. As explained later, a flow

control valve which is capable of adjusting the amount of air injected from the nozzle 10 may be used instead of the shut off valve 11.

[0060] In this embodiment, the internal combustion engine 1 is operated at an air-fuel ratio near the stoichiometric air-fuel ratio and the air-fuel ratio of the exhaust gas from the engine 1 is usually maintained at the stoichiometric air-fuel ratio. Since the three-way reducing and oxidizing catalyst 3 can resolve the HC, CO and NO_x components in the exhaust gas at a high efficiency when the air-fuel ratio is near the the secondary air supply unit 9.

[0061] Usually, the temperature of the exhaust gas at the outlet of the engine 1 is above the optimum temperature range of the NH₃ decomposing catalyst 7. However, the temperature of the exhaust gas becomes lower as the exhaust gas flows down the exhaust gas passage due to the heat dissipation through the wall of the exhaust gas passage 2. Further, when it passes through the muffler 5, the exhaust gas is cooled by the muffler 5. Therefore, the temperature of the exhaust gas when it reaches the NH₃ decomposing catalyst 7 is lower than the temperature at the outlet of the engine 1. In this embodiment, the length of the exhaust gas passage between the engine 1 and the NH₃ decomposing catalyst 7 as well as the capacity of the muffler 5 is determined in such a manner that the temperature of the exhaust gas at the inlet of the NH₃ decomposing catalyst 7 falls in the optimum temperature range even when the engine 1 is operated at the maximum exhaust temperature conditions. By this arrangement, the temperature of the exhaust gas flowing into the NH₃ decomposing catalyst 7, and the temperature of the NH₃ decomposing catalyst 7 accordingly, is always maintained within the optimum temperature range regardless of the change in the operating conditions of the engine 1.

[0062] Further, the air-fuel ratio of the exhaust gas flowing into the NH₃ decomposing catalyst 7 is adjusted by supplying air from the secondary air supply unit 9 so that the air-fuel ratio of the exhaust gas becomes lean compared to the stoichiometric air-fuel ratio. As explained before, when the exhaust gas flowing into the NH₃ decomposing catalyst 7 is in an oxidizing atmosphere (i.e., at a lean air-fuel ratio), the NH₃ decomposing catalyst 7 is capable of decomposing substantially all of the NH₃ in the exhaust gas regardless of the degree of the leanness of the air-fuel ratio of the exhaust gas. Therefore, it is not necessary to control the amount of air supplied from the secondary air supply unit 9 in order to strictly control the air-fuel ratio of the exhaust gas flowing into the NH₃ decomposing catalyst 7 in this embodiment. The amount of the air supplied from the secondary air supply unit 9 is set at an amount which can keep the air-fuel ratio of the exhaust gas flowing into the NH₃ decomposing catalyst 7 on a lean air-fuel ratio side compared to the stoichiometric air-fuel ratio even when the operating air-fuel ratio of the engine 1 fluctuates to the rich air-fuel ratio side compared to the stoichiometric

air-fuel ratio.

[0063] By the arrangement explained above, the exhaust gas supplied to the NH₃ decomposing catalyst 7 is always an oxidizing atmosphere and has a temperature within the optimum temperature range. Therefore, even if NH₃ is formed at the three-way reducing and oxidizing catalyst 3, NH₃ is completely resolved by the NH₃ decomposing catalyst 7. Further, when the air-fuel ratio of the exhaust gas becomes rich, the capability of the three-way reducing and oxidizing catalyst 3 for resolving HC and CO component in the exhaust gas decreases. However, according to the present embodiment, HC and CO components passing through the three-way reducing and oxidizing catalyst 3 are also resolved by the NH₃ decomposing catalyst 7. Therefore, according to the present embodiment, an increase in the emission of HC, CO and NH₃ components when the operating air-fuel ratio of the engine fluctuates to rich side can be prevented.

[0064] Though the temperature of the exhaust gas is adjusted by the heat dissipation from the wall of the exhaust gas passage 2 and the cooling by the muffler 5 in this embodiment, other means for adjusting the temperature of the exhaust gas may be used. For example, heat radiation fins may be disposed outer wall of the exhaust gas passage 2 instead of, or in addition to the muffler 5, or alternatively, the wall of the exhaust gas passage 2 may be water-cooled to increase the cooling capacity of the exhaust gas passage 2. Further, the amount of the air supplied from the secondary air supply unit 9 may be changed in accordance with the temperature of the exhaust gas to maintain the temperature of the exhaust gas flowing into the NH₃ decomposing catalyst 7 within the optimum temperature range by using a flow control valve instead of the shut off valve 11 in this embodiment. Further, the flow amount of the cooling water for cooling the exhaust gas passage wall, or the amount of the air supplied from the secondary air supply unit may be feedback controlled in accordance with an output signal of a temperature sensor detecting the catalyst bed of the NH₃ decomposing catalyst 7 in such a manner that the temperature of the NH₃ decomposing catalyst is maintained within the optimum temperature range.

[0065] In the above embodiment, if the operating air-fuel ratio of the engine 1 fluctuates to a lean air-fuel ratio side compared to the stoichiometric air-fuel ratio, NH₃ is not formed at the three-way reducing and oxidizing catalyst 3, and the capability of the three-way reducing and oxidizing catalyst for reducing NO_x also decreases. In this case, an exhaust gas which contains NO_x, but does not contain NH₃ flows into the NH₃ decomposing catalyst 7. This causes the NO_x in the exhaust gas to pass through the NH₃ decomposing catalyst 7 without being reduced. Therefore, to prevent the emission of the NO_x when the operating air-fuel ratio becomes lean, a NO_x absorbent which is capable of absorbing NO_x in the exhaust gas of a lean air-fuel ratio, or a NO_x reducing

catalyst which has a capability for selectively reducing the NO_x in the exhaust gas even in an oxidizing atmosphere may be disposed on the exhaust gas passage 2 between the three-way reducing and oxidizing catalyst 3 and the NH_3 decomposing catalyst 7. Fig. 7 shows an embodiment of the present invention in which a NO_x absorbent or a NO_x reducing catalyst is disposed on the exhaust gas passage 2 between the three-way reducing and oxidizing catalyst 3 and the NH_3 decomposing catalyst 7. In Fig. 7, same reference numerals as those in Fig. 1 represent same elements. Reference numeral 8 in Fig. 7 designates an NO_x absorbent or NO_x reducing catalyst disposed on the exhaust gas passage between the three-way reducing and oxidizing catalyst 3 and the NH_3 decomposing catalyst 7 (in Fig. 7, the NO_x absorbent 8 or the NO_x reducing catalyst is disposed between the three-way reducing and oxidizing catalyst 3 and the muffler 5. However, the NO_x absorbent 8 or the NO_x reducing catalyst may be disposed between the muffler 5 and the NH_3 decomposing catalyst 7). In this embodiment, when the operating air-fuel ratio of the engine fluctuates to lean side, NO_x passes through the three-way reducing and oxidizing catalyst 7 is absorbed by the NO_x absorbent 8 or reduced by the NO_x reducing catalyst 8. Therefore, NO_x is not contained in the exhaust gas flowing into the NH_3 decomposing catalyst 7 even when the operating air-fuel ratio of the engine fluctuates to lean air-fuel ratio side. Though the NO_x absorbent 8 in this embodiment is disposed on the exhaust gas passage 2 separately, it is possible to give the absorbing and releasing capability of NO_x to the substrate of the NH_3 decomposing catalyst. This is accomplished by attaching the NO_x absorbing substances (explained later) to the substrate of the NH_3 decomposing catalyst 7 in addition to the catalytic components.

[0066] The NO_x absorbent and the NO_x reducing catalyst will be explained later in detail.

[0067] Next, another embodiment of the present invention is explained. Though the engine 1 in the previous embodiment is operated near the stoichiometric air-fuel ratio, the engine in this embodiment is operated at a slightly rich air-fuel ratio in such a manner that an excess air ratio λ falls in the range between 0.95 and 0.98. Since the construction of the device of the present embodiment is the same as that of the previous embodiment, the present embodiment is also explained with reference to Fig. 1.

[0068] In the previous embodiment, the operating air-fuel ratio of the engine 1 fluctuates to the lean air-fuel ratio side as well as to the rich air-fuel ratio side due to the change in the operating conditions. When the operating air-fuel ratio of the engine becomes lean, the NO_x components in the exhaust gas pass through the three-way reducing and oxidizing catalyst 3 without being reduced. Further, since the three-way reducing and oxidizing catalyst 3 does not produce NH_3 when the air-fuel ratio of the exhaust gas is lean, the NH_3 decomposing catalyst 7 cannot resolve the NO_x components in the

exhaust gas. To prevent this, the engine 1 in this embodiment is operated at slightly rich air-fuel ratio so that the operating air-fuel ratio does not become lean compared to the stoichiometric air-fuel ratio even when the operating air-fuel ratio of the engine 1 fluctuates to some extent.

[0069] Since the engine 1 is operated at a rich air-fuel ratio in normal operation, NH_3 is formed at the three-way reducing and oxidizing catalyst 3 during the normal operation of the engine 1, and the amounts of the HC, CO components in the exhaust gas also increases in the normal operation of the engine 1 in this embodiment. However, the NH_3 formed at the three-way reducing and oxidizing catalyst 3 and the HC, CO components passes through the three-way reducing and oxidizing catalyst 3 are both resolved by the NH_3 decomposing catalyst 7 in this embodiment. Therefore, the emission of NH_3 , as well as HC and CO, does not occur in this embodiment. As explained above, according to the present embodiment, the emission of the NH_3 , HC and CO components are reduced by operating the engine 1 at a slightly rich air-fuel ratio.

[0070] Next, another embodiment is explained with reference to Fig. 2.

[0071] In Fig. 2, the same reference numerals as those in Fig. 1 represent the same elements. The embodiment in Fig. 2 is different from the embodiment in Fig. 1 in that an NO_x absorbent 8 is disposed on the exhaust gas passage 2 downstream of the NH_3 decomposing catalyst 7. The NO_x absorbent 8 absorbs NO_x in the exhaust gas when the air-fuel ratio of the exhaust gas is lean compared to the stoichiometric air-fuel ratio. The NO_x absorbent 8 in this embodiment uses, for example, alumina as a carrier and, on this carrier, precious metals such as platinum (Pt) rhodium (Rh), and at least one substance selected from alkali metals such as potassium (K), sodium (Na), lithium (Li) and cesium (Cs); alkali-earth metals such as barium (Ba) and calcium (Ca); and rare-earth metals such as lanthanum (La) and yttrium (Y) is carried. The NO_x absorbent 8 absorbs NO_x in the exhaust gas when the air-fuel ratio of the exhaust gas is lean, and releases the absorbed NO_x when the oxygen concentration of the exhaust gas flowing the NO_x absorbent becomes lower.

[0072] Though the mechanism of this absorption and releasing operation of the NO_x absorbent is not clear at present, it is considered that the absorption and releasing operation is conducted by the following mechanism. Though the following mechanism of the absorption and the releasing operation of the NO_x absorbent is explained for the case where platinum Pt and barium (Ba) are carried on the carrier, as an example, it is considered that a similar mechanism also applies even if other precious metal, alkali metals, alkali earth metals, or rare earth metals are used.

[0073] Namely, when the concentration of O_2 in the exhaust gas increases, i.e., when the air-fuel ratio of the exhaust gas becomes lean, the oxygen O_2 in the ex-

haust gas is deposited on the surface of platinum (Pt) in the form of O_2^- or O^{2-} . The NO in the exhaust gas reacts with O_2^- or O^{2-} on the surface of the platinum (Pt) and becomes NO_2 ($2NO + O_2 \rightarrow 2NO_2$). Then, NO_2 in the exhaust gas and the NO_2 produced on the platinum (Pt) are further oxidized on the surface of platinum (Pt) and absorbed into the NO_x absorbent while bonding with the barium oxide (BaO) and diffusing in the absorbent in the form of nitric acid ions NO_3^- . Thus, NO_x in the exhaust gas is absorbed by the NO_x absorbent 8 when the air-fuel ratio of the exhaust gas is lean.

[0074] On the other hand, when the oxygen concentration in the exhaust gas becomes low, i.e., when the air-fuel ratio of the exhaust gas becomes rich, the production of NO_2 on the surface of the platinum (Pt) is lowered and the reaction proceeds in an inverse direction ($NO_3^- \rightarrow NO_2$), and thus nitric acid ions NO_3^- in the absorbent are released in the form of NO_2 from the NO_x absorbent 8.

[0075] In this case, if the reducing substance such as NH_3 and CO, or the substance such as HC and CO_2 exist in the exhaust gas, the released NO_x is reduced on the platinum Pt by these components. Namely, the NO_x absorbent 8 performs the absorbing and releasing operation of the NO_x in the exhaust gas in which the NO_x in the exhaust gas is absorbed by the NO_x absorbent when the air-fuel ratio of the exhaust gas is lean and released from the NO_x absorbent when the air-fuel ratio of the exhaust gas becomes rich.

[0076] As explained in Fig. 6, the NH_3 decomposing catalyst 7 converts the NH_3 in the exhaust gas to NO_x when the temperature becomes higher than the optimum temperature range. Therefore, if the exhaust gas temperature at the outlet of the engine 1 becomes very high in an extreme operating condition of the engine 1, the temperature maintaining means such as the muffler 5 might be insufficient to lower the exhaust gas temperature to the optimum temperature range of the NH_3 decomposing catalyst 7. In such a case, since the temperature of the exhaust gas flowing into the NH_3 decomposing catalyst 7 exceeds the optimum temperature range, NO_x is formed at the NH_3 decomposing catalyst 7 and is discharged to atmosphere.

[0077] In this embodiment, the NO_x absorbent 8 is disposed on the exhaust gas passage 2 downstream of the NH_3 decomposing catalyst 7 to prevent the emission of the NO_x in the extremely high exhaust gas temperature conditions. Since the NO_x absorbent 8 absorbs the NO_x in the exhaust gas in an oxidizing atmosphere, the NO_x formed at the NH_3 decomposing catalyst 7 in the extremely high exhaust gas temperature condition is absorbed by the NO_x absorbent 8 and the emission of the NO_x to the atmosphere does not occur.

[0078] As explained above, according to the present embodiment, the exhaust emission can be always kept low even when the exhaust gas temperature becomes extremely high.

[0079] Though the NO_x absorbent 8 in the above em-

bodiment is disposed on the exhaust gas passage 2 separately, it is possible to give the absorbing and releasing capability of NO_x to the substrate of the NH_3 decomposing catalyst. This is accomplished by attaching the NO_x absorbing substances such as alkali metals and alkali-earth metals to the substrate of the NH_3 decomposing catalyst 7 in addition to the catalytic components.

[0080] Next, another embodiment of the present invention is explained. In this embodiment, an NO_x reducing catalyst is disposed on the exhaust gas passage downstream of the NH_3 decomposing catalyst 7 instead of the NO_x absorbent 8 in Fig. 2. Other constructions of this embodiment are the same as those in Fig. 2. Therefore, illustration of this embodiment by drawings is omitted.

[0081] The NO_x reducing catalyst in this embodiment has a substrate made of, for example, zeolite ZSM-5, and metals such as copper (Cu) and iron (Fe) are attached to the substrate by an ion exchange method. Alternatively, a substrate made of zeolite such as mordenite and precious metal such as platinum (Pt) attached thereon can also be used as the NO_x reducing catalyst. The NO_x reducing catalyst traps NH_3 , HC and CO components in the exhaust gas in the pores of the porous zeolite, and selectively reduces the NO_x in the exhaust gas using these trapped components even in an oxidizing atmosphere.

[0082] In this embodiment, the NO_x reducing catalyst is disposed at downstream of the NH_3 decomposing catalyst 7 in Fig. 2 traps the NH_3 component in the exhaust gas which passes through the NH_3 decomposing catalyst 7 when the exhaust gas temperature is below the optimum temperature range as well as the HC and CO components in the exhaust gas. Further, when the exhaust gas temperature is above the optimum temperature range, the NO_x reducing catalyst selectively reduces the NO_x formed at the NH_3 decomposing catalyst 7 using the trapped NH_3 , HC and CO components. Therefore, according to the present embodiment, the NO_x formed at the NH_3 decomposing catalyst in the high exhaust gas temperature conditions is not emitted to atmosphere and the exhaust emissions are always maintained at low level regardless of the change in the operating conditions of the engine.

[0083] Next another embodiment of the present invention is explained with reference to Fig. 3. In Fig. 3, the same reference numerals as those in Fig. 1 designate the same elements.

[0084] In this embodiment, means for cooling the exhaust gas such as the muffler 5 in Fig. 1 is not used. Further, a plurality of the NH_3 decomposing catalyst are disposed on the exhaust gas passage 2 downstream of the three-way reducing and oxidizing catalyst 3 (Fig. 3 shows the case in which three NH_3 decomposing catalyst 7a to 7c are used). Also, the secondary air supply unit 9 in this embodiment has a plurality of the nozzles 10a to 10c which are each disposed, in the exhaust gas passage 2, at the inlet of the respective NH_3 decompos-

ing catalysts 7a to 7c. Reference numeral 30 in Fig. 3 designates a control circuit of the engine 1. The control circuit 30 may be comprises, for example, a micro-computer of known type and performs basic controls of the engine 1 such as a fuel injection control and an ignition timing control. In this embodiment, the control circuit 30 also act as selecting means which selects the nozzles of the secondary air supply unit 9 in accordance with the exhaust gas temperature discharged from the engine 1 to supply air to the NH_3 decomposing catalysts which is in the optimum temperature range. To perform these controls, signals representing the operating condition of the engine 1 such as the inlet air flow amount and the speed of the engine 1 are fed to the control circuit 30 from the respective sensors not shown in the drawing. Further, the control circuit 30 is connected to shut off valves 11a to 11c which are disposed on the piping connecting the pressurized air source 9a and the respective nozzles 10a to 10c to control the operation of these shut off valves.

[0085] The temperature of the exhaust gas becomes lower as it flows down the exhaust gas passage 2 due to the heat dissipation through the passage wall during the operation of the engine 1. Since plural NH_3 decomposing catalysts are disposed on the exhaust gas passage 2 in series in this embodiment, the temperature of the exhaust gas flowing into the respective NH_3 decomposing catalysts are different. Therefore, the temperature of the respective NH_3 decomposing catalysts are also different from each other in this embodiment. Further, the length of the exhaust gas passage 2 between the engine 1 and the respective NH_3 decomposing catalysts are determined in such a manner that the temperature of at least one NH_3 decomposing catalysts falls in the optimum temperature range throughout the whole operating range of the engine 1. Namely, at least one NH_3 decomposing catalyst is maintained at a temperature within the optimum temperature range in this embodiment regardless of the change in the operating conditions of the engine 1.

[0086] During the operation of the engine 1, the control circuit 30 determines the temperature of the respective NH_3 decomposing catalysts based on the operating conditions of the engine, and supplies air to the NH_3 decomposing catalyst(s) which has a temperature within the optimum temperature range by activating the shut off valve connected to the nozzle at the inlet of that NH_3 decomposing catalyst(s). Thus, secondary air is supplied only to the NH_3 decomposing catalyst(s) which has a temperature within the optimum temperature range. The temperature of the respective NH_3 decomposing catalysts change in accordance with the temperature of the exhaust gas at the outlet of the engine 1 (i.e., the engine load) and the amount of the exhaust gas flow (i.e., the engine speed). In this embodiment, the temperature of the respective NH_3 decomposing catalysts are previously measured using the actual engine under various engine loads and speed conditions, and the NH_3

decomposing catalysts to which air is supplied (i.e., the NH_3 decomposing catalysts having a temperature within the optimum temperature range) are determined previously in accordance with the engine load and speed and stored in the memory of the control circuit 30. The control circuit 30 determines the NH_3 decomposing catalysts to which the air should be supplied, in accordance with the engine load and speed during the engine operation, and opens the shut off valves connected to the air nozzles at the inlet of those NH_3 decomposing catalysts.

[0087] Therefore, according to the present embodiment, the NO_x and the NH_3 in the exhaust gas are effectively resolved regardless of the change in the exhaust gas temperature at the outlet of the engine by using the NH_3 decomposing catalyst which has the temperature within the optimum temperature range. Further, it is known that the catalytic components of the NH_3 decomposing catalyst which are precious metals such as platinum (Pt), rhodium (Rh) and palladium (Pd) also act as three-way reducing and oxidizing catalyst when the temperature is higher than the optimum temperature range. Therefore, these precious metal catalytic components may be used for the NH_3 decomposing catalysts located upstream (for example, NH_3 decomposing catalysts 7a and 7b in Fig. 3). In this case, the upstream NH_3 decomposing catalysts act as supplementary three-way reducing and oxidizing catalysts when the temperature of the upstream NH_3 decomposing catalysts are higher than the optimum temperature range, and the NH_3 and NO_x in the exhaust gas are resolved by the NH_3 decomposing catalysts located downstream.

[0088] Though three NH_3 decomposing catalysts are used in the present embodiment, the number of the NH_3 decomposing catalysts is not limited to three, i.e., two or more NH_3 decomposing catalysts may be used in accordance with the type of the engine and the arrangement of the exhaust gas system. Further, the catalytic components used for the NH_3 decomposing catalysts may be the same for all the NH_3 decomposing catalysts, or different components for respective NH_3 decomposing catalysts may be used. Further, means for cooling the exhaust gas such as the muffler 5 used in the embodiment in Fig. 1 can be used also in this embodiment to lower the exhaust gas temperature.

[0089] Further, though the control circuit 30 selects the NH_3 decomposing catalysts having a temperature within the optimum temperature range based on the operating condition of the engine 1, the NH_3 decomposing catalyst may be selected based on the actual temperature measured by temperature sensors disposed on the exhaust gas passage at the inlet of the respective NH_3 decomposing catalysts, or by temperature sensors disposed on the catalyst beds of the respective NH_3 decomposing catalysts.

[0090] Next, another embodiment of the present invention is explained with reference to Fig. 4. In the embodiments explained above, the present invention is applied to the system in which the internal combustion en-

gine is operated at the air-fuel ratio near the stoichiometric air-fuel ratio, or lower than the stoichiometric air-fuel ratio (i.e., the rich air-fuel ratio). However, in this embodiment, the present invention is applied to an engine operated at an air-fuel ratio higher than the stoichiometric air-fuel ratio (i.e., a so-called lean burn engine).

[0091] In Fig. 4, reference numeral 41 designates a lean burn engine which is operated at an air-fuel ratio higher than the stoichiometric air-fuel ratio, 42 designates an exhaust gas passage of the engine 41. A muffler 45 and a NH_3 decomposing catalyst 47 which are similar to the muffler 5 and the NH_3 decomposing catalyst 7 in Fig. 1, respectively, are disposed on the exhaust gas passage 42. However, a three-way reducing and oxidizing catalyst 3 as shown in Fig. 5 is not provided in this embodiment. Further, instead of the secondary air supply unit 9 in Fig. 1, an NH_3 supply unit 49 which comprises a nozzle 50 and a shut off valve 51 which are similar to those in Fig. 1 and a NH_3 supply source 49a such as a bottle containing gaseous or liquid NH_3 is provided in this embodiment.

[0092] In this embodiment, the exhaust gas in an oxidizing atmosphere from the lean burn engine 41 is cooled by the muffler 45 and flows into the NH_3 decomposing catalyst 47 at the temperature within the optimum temperature range. Further, NH_3 is added to the exhaust gas at the portion upstream of the NH_3 decomposing catalyst 47. The exhaust gas from the lean burn engine 41 contains a relatively large amount of NO_x . Thus, the exhaust gas flowing into the NH_3 decomposing catalyst is adjusted so that it becomes an oxidizing atmosphere and a temperature within the optimum temperature range. Further, the exhaust gas contains NO_x and NH_3 . Therefore, both the NO_x and the NH_3 in the exhaust gas are completely resolved by the NH_3 decomposing catalyst 47.

[0093] As explained before, the capability of the three-way reducing and oxidizing catalyst for reducing the NO_x becomes very small when the exhaust gas is in an oxidizing atmosphere. Therefore, it is difficult to decompose the NO_x in the exhaust gas of the lean burn engine using the three-way reducing and oxidizing catalyst. However, according to the present invention, the NO_x in the exhaust gas from the lean burn engine can be completely decomposed by the NH_3 decomposing catalyst 47.

[0094] Further, the method for decomposing NO_x in the exhaust gas of in an oxidizing atmosphere by adding an NH_3 component to the exhaust gas and using a conventional vanadia-titania ($\text{V}_2\text{O}_5\text{-TiO}_2$) type denitrating catalyst is known in the art. In the above conventional method, NO_x and NH_3 are converted to N_2 and H_2O by the denitrating reactions ($8\text{NH}_3 + 6\text{NO}_2 \rightarrow 12\text{H}_2\text{O} + 7\text{N}_2$ and/or $4\text{NH}_3 + 4\text{NO}_2 + \text{O}_2 \rightarrow 6\text{H}_2\text{O} + 4\text{N}_2$). However, in the conventional method, the amount of NO_x components and the NH_3 component must be adjusted so that the ratio of the moles of NO_x and NH_3 are strictly stoichiometrical (i.e., 4:3 or 1:1) in order to react NO_x with

NH_3 without causing any surplus NO_x and NH_3 , as explained before.

[0095] However, in the actual operation of the engine, the concentration of the NO_x components in the exhaust gas varies widely in accordance with the operating condition of the engine, and it is difficult to control the amount of the NH_3 added to the exhaust gas in accordance with the concentration of the NO_x in the exhaust gas. Therefore, if the conventional method is used for an actual engine, NO_x or NH_3 is emitted to the atmosphere in some cases.

[0096] However, in case of the NH_3 decomposing catalyst 47 in this embodiment, it is not required to strictly control the amount of the NH_3 added to the exhaust gas since the NH_3 decomposing catalyst can convert all of the NH_3 in the exhaust gas as long as the exhaust gas is in an oxidizing atmosphere. In this embodiment, it is only required that the amount of the NH_3 added to the exhaust gas is sufficiently large to reduce all of the NO_x in the exhaust gas while maintaining the exhaust gas in an oxidizing atmosphere. Therefore, according to the present embodiment, the NO_x in the exhaust gas of the lean burn engine can be completely resolved by a simple control of the NH_3 supply unit 49 while preventing the emission of NH_3 .

[0097] Fig. 5 shows another embodiment of the present invention which is similar to the embodiment in Fig. 3. In this embodiment, a plurality of the NH_3 decomposing catalysts (47a to 47c in Fig. 5) and NH_3 supply nozzles (50a to 50c in Fig. 5) are disposed on the exhaust gas passage 42. Similarly to the embodiment in Fig. 3, the control circuit 30 selects the NH_3 decomposing catalyst which is in the optimum temperature range according to the operating conditions of the engine 41, and supplies NH_3 to those NH_3 decomposing catalysts through the NH_3 nozzle located at the inlet of those NH_3 decomposing catalysts. Since the operation of the present embodiment is substantially the same as the operation of the embodiment in Fig. 3, a detailed explanation is not given here.

[0098] From the description set forth above, it will be understood that, according to the present invention, the NH_3 and NO_x components contained in the combustion exhaust gas can be decomposed effectively by the NH_3 decomposing catalyst. Though the present invention is explained using the embodiments in which the present invention is applied to the internal combustion engine, the application of the present invention is not limited to the internal combustion engine. The present invention can be also applied to decompose the NH_3 and NO_x components in the exhaust gas discharged from the combustion devices other than the internal combustion engine. Namely, the present invention can be also applied to, for example, boilers, furnaces etc., which emit combustion exhaust gases.

Claims

1. A process for decomposing an NH_3 component in a combustion exhaust gas by contacting a combustion exhaust gas containing a NH_3 component in an oxidizing atmosphere at a temperature within a predetermined range with an NH_3 decomposing catalyst which decomposes the NH_3 component in an exhaust gas in an oxidizing atmosphere without substantially producing NO_x components in said oxidizing atmosphere when the temperature of the catalyst is in said predetermined temperature range, wherein said predetermined temperature range is defined so that at catalyst temperatures higher than said predetermined temperature range said NH_3 decomposing catalyst converts the NH_3 component in the exhaust gas in an oxidizing atmosphere to NO_x components and so that at catalyst temperatures lower than said predetermined temperature range said NH_3 decomposing catalyst allows the NH_3 component in the exhaust gas in an oxidizing atmosphere to pass through the catalyst.
 2. The process according to claim 1 further comprising before said step of contacting said combustion exhaust gas in an oxidizing atmosphere in said predetermined temperature range with said NH_3 decomposing catalyst:
 - contacting an exhaust gas of an internal combustion engine in a reducing atmosphere with an NH_3 synthesizing catalyst which converts NO_x components in the exhaust gas in a reducing atmosphere to an NH_3 component; and adjusting the conditions of the exhaust gas after it has contacted the NH_3 synthesizing catalyst so that the exhaust gas is in an oxidizing atmosphere and within said predetermined temperature range.
 3. The process according to claim 2, wherein said internal combustion engine is operated at an air-fuel ratio close to the stoichiometric air-fuel ratio, and wherein a three-way reducing and oxidizing catalyst is used as said NH_3 synthesizing catalyst.
 4. The process according to claim 2, wherein said internal combustion engine is operated at an air-fuel ratio lower than the stoichiometric air-fuel ratio, and a three-way reducing and oxidizing catalyst is used as said NH_3 synthesizing catalyst.
 5. The process according to claim 2, further using an NO_x absorbent which absorbs NO_x components in the exhaust gas in an oxidizing atmosphere, and further comprising a step of contacting said exhaust gas to the NO_x absorbent after the exhaust gas has contacted the NH_3 synthesizing catalyst and before the exhaust gas contacts the NH_3 decomposing catalyst.
 6. The process according to claim 2, further using an NO_x reducing catalyst which selectively reduces NO_x components in the exhaust gas in an oxidizing atmosphere, and further comprising a step of contacting said exhaust gas to the NO_x reducing catalyst after the exhaust gas has contacted the NH_3 synthesizing catalyst and before the exhaust gas contacts the NH_3 decomposing catalyst.
 7. The process according to claim 1 or 2, wherein said NH_3 decomposing catalyst contains an NH_3 adsorbing component which adsorbs an NH_3 component in the exhaust gas.
 8. The process according to claim 7, wherein said NH_3 adsorbing component adsorbs an NH_3 component in the exhaust gas when the temperature is lower than said predetermined temperature range.
 9. A device for decomposing an NH_3 component contained in the exhaust gas of an internal combustion engine (1) comprising:
 - an NH_3 decomposing catalyst (7) disposed in an exhaust gas passage (2) of an internal combustion engine, said NH_3 decomposing catalyst decomposes an NH_3 component in an exhaust gas flowing into the catalyst in an oxidizing atmosphere without substantially producing NO_x components in said oxidizing atmosphere when the temperature of the catalyst is in a predetermined temperature range, wherein said predetermined temperature range is defined so that at catalyst temperatures higher than said predetermined temperature range said NH_3 decomposing catalyst converts the NH_3 component in the exhaust gas in an oxidizing atmosphere to NO_x components and so that at catalyst temperatures lower than said predetermined temperature range said NH_3 decomposing catalyst allows the NH_3 component in the exhaust gas in an oxidizing atmosphere to pass through the catalyst;
 - oxygen supply means (9) for supplying oxygen to the exhaust gas flowing into said NH_3 decomposing catalyst so that the exhaust gas flowing into said NH_3 decomposing catalyst becomes oxidizing atmosphere; and
 - temperature maintaining means for maintaining the temperature of the exhaust gas flowing into said NH_3 decomposing catalyst within said predetermined temperature range regardless of a change in the temperature of the exhaust gas discharged from the internal combustion engine.

10. The device according to claim 9, further comprising an NO_x absorbent (8) which absorbs NO_x components in the exhaust gas in an oxidizing atmosphere and is disposed on the exhaust gas passage downstream of said NH₃ decomposing catalyst. 5
11. The device according to claim 9, further comprising an NO_x reducing catalyst (8) which selectively reduces NO_x components in the exhaust gas in an oxidizing atmosphere and is disposed on the exhaust gas passage downstream of said NH₃ decomposing catalyst. 10
12. The device according to claim 9, comprising: 15
- a plurality of NH₃ decomposing catalysts (7) disposed in an exhaust gas passage (2) of an internal combustion engine in series arrangement, each of said NH₃ decomposing catalysts decomposing an NH₃ component in the exhaust gas flowing into the catalyst in an oxidizing atmosphere without substantially producing NO_x components in said oxidizing atmosphere when the temperature of the catalyst is in said predetermined temperature range; 20
- said oxygen supply means (8) supplying oxygen selectively to the exhaust gas flowing into the respective NH₃ decomposing catalysts; 25
- said temperature detecting means detecting the temperature of the respective NH₃ decomposing catalysts, and 30
- selecting means (30) for controlling said oxygen supply means in such a manner that the oxygen supply means supplies oxygen to the exhaust gas flowing into the NH₃ decomposing catalyst(s) whose temperature is within said predetermined temperature range. 35
13. The device according to claim 9, additionally comprising: 40
- an NH₃ synthesizing catalyst (3) disposed on an exhaust gas passage of the engine upstream of said NH₃ decomposing catalyst, wherein said NH₃ synthesizing catalyst converts NO_x components in the exhaust gas discharged from the engine to NH₃ and N₂ components when the operating air-fuel ratio of the engine is lower than the stoichiometric air-fuel ratio; and 45
- by said NH₃ decomposing catalyst (7) disposed on the exhaust gas passage downstream of the NH₃ synthesizing catalyst, the NH₃ component produced by the NH₃ synthesizing catalyst (3) is adsorbed when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio and wherein said NH₃ decomposing catalyst (7) reduces NO_x components in the exhaust 50

gas discharged from the engine and pass through the NH₃ synthesizing catalyst (3) when the operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio by reacting the NO_x components with the NH₃ component adsorbed in the NH₃ decomposing catalyst (7), wherein in said device the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio in such a manner that the average operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio.

14. The device according to claim 9, additionally comprising: 15

an NH₃ synthesizing catalyst (3) disposed on an exhaust gas passage of the engine, wherein said NH₃ synthesizing catalyst converts NO_x components in the exhaust gas discharged from the engine to NH₃ and N₂ components when the operating air-fuel ratio of the engine is lower than the stoichiometric air-fuel ratio; an NO_x absorbent (8) disposed on the exhaust gas passage downstream of the NH₃ synthesizing catalyst (3), wherein said NO_x absorbent absorbs NO_x components in the exhaust gas discharged from the engine and pass through the NH₃ synthesizing catalyst when the operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio and releases the absorbed NO_x components when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio; and said NH₃ decomposing catalyst (7) is disposed on the exhaust gas passage downstream of the NO_x absorbent (8), wherein, when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio, said NH₃ decomposing catalyst reduces the NO_x components released from the NO_x absorbent by reacting said NO_x components with the NH₃ component produced by the NH₃ synthesizing catalyst, wherein in said device the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio in such a manner that the average operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio.

15. A device according to claim 9, additionally comprising: 50

an NH₃ synthesizing catalyst (3) disposed on an exhaust gas passage of the engine, wherein said NH₃ synthesizing catalyst converts NO_x components in the exhaust gas discharged from the engine to NH₃ and N₂ components when the operating air-fuel ratio of the engine 55

is lower than the stoichiometric air-fuel ratio; said NH_3 decomposing catalyst (7) is disposed on the exhaust gas passage downstream of the NH_3 synthesizing catalyst, wherein said NH_3 decomposing catalyst absorbs NO_x components in the exhaust gas discharged from the engine and pass through the NH_3 synthesizing catalyst (3) when the operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio and wherein said NH_3 decomposing catalyst (7) reduces the absorbed NO_x components by reacting said NO_x components with the NH_3 component produced by the NH_3 synthesizing catalyst (3) when the engine operating air-fuel ratio is lower than the stoichiometric air-fuel ratio, wherein in said device the operating air-fuel ratio of the engine fluctuates around the stoichiometric air-fuel ratio in such a manner that the average operating air-fuel ratio of the engine is higher than the stoichiometric air-fuel ratio.

16. A device according to claim 9 or 12, wherein said NH_3 decomposing catalyst contains an NH_3 adsorbing component which adsorbs an NH_3 component in the exhaust gas.
17. A device according to claim 16, wherein said NH_3 adsorbing component adsorbs an NH_3 component in the exhaust gas when the temperature is lower than said predetermined temperature range.
18. A device according to claim 16, wherein said NH_3 adsorbing component comprises an acidic inorganic substance.
19. A device according to claim 16, wherein said NH_3 adsorbing component comprises at least one substance selected from zeolite, silica (SiO_2), titania (TiO_2), silica-alumina ($\text{SiO}_2\text{-Al}_2\text{O}_3$), copper (Cu), cobalt (Co), nickel (Ni) and iron (Fe).

Patentansprüche

1. Verfahren zum Abbau einer NH_3 -Komponente in einem Verbrennungsabgas, indem ein eine NH_3 -Komponente enthaltendes Verbrennungsabgas in einer oxidierenden Atmosphäre bei einer Temperatur innerhalb eines vorherbestimmten Bereichs mit einem NH_3 abbauenden Katalysator in Kontakt gebracht wird, welcher die NH_3 -Komponente in einem Abgas in einer oxidierenden Atmosphäre abbaut, ohne im wesentlichen NO_x -Komponenten in der oxidierenden Atmosphäre herzustellen, wenn die Temperatur des Katalysators in dem vorherbestimmten Bereich ist, wobei der vorherbestimmte Temperaturbereich derart definiert ist, dass bei Ka-

talysatortemperaturen, die höher sind als der vorherbestimmte Temperaturbereich, der NH_3 abbauende Katalysator die NH_3 -Komponente in dem Abgas in einer oxidierenden Atmosphäre zu NO_x -Komponenten umwandelt, und derart definiert ist, dass bei Katalysatortemperaturen, die niedriger sind als der vorherbestimmte Temperaturbereich, der NH_3 abbauende Katalysator es ermöglicht, dass die NH_3 -Komponente im Abgas in einer oxidierenden Atmosphäre durch den Katalysator tritt.

2. Verfahren gemäß Anspruch 1, das außerdem vor der Stufe des in Kontakt Bringens des Verbrennungsabgases mit dem NH_3 abbauenden Katalysator in einer oxidierenden Atmosphäre in dem vorherbestimmten Temperaturbereich folgendes umfasst:

In Kontakt bringen eines Abgases eines Verbrennungsmotors in einer reduzierenden Atmosphäre mit einem NH_3 synthetisierenden Katalysator, welcher NO_x -Komponenten in dem Abgas in einer reduzierenden Atmosphäre in eine NH_3 -Komponente umwandelt; und Einstellen der Bedingungen des Abgases nachdem dieses den NH_3 synthetisierenden Katalysator kontaktiert hat, derart, dass das Abgas in einer oxidierenden Atmosphäre und innerhalb des vorherbestimmten Temperaturbereichs vorliegt.

3. Verfahren gemäß Anspruch 2, wobei der Verbrennungsmotor bei einem Luft-Treibstoffverhältnis betrieben wird, das nahe bei dem stöchiometrischen Luft-Treibstoffverhältnis liegt, und wobei ein reduzierender und oxidierender Drei-Wege-Katalysator als der NH_3 synthetisierende Katalysator verwendet wird.
4. Verfahren gemäß Anspruch 2, wobei der Verbrennungsmotor bei einem Luft-Treibstoffverhältnis betrieben wird, das niedriger als das stöchiometrische Luft-Treibstoff-Verhältnis ist, und wobei ein reduzierender und oxidierender Drei-Wege-Katalysator als der NH_3 synthetisierende Katalysator verwendet wird.
5. Verfahren gemäß Anspruch 2, wobei außerdem ein NO_x -Absorbtionsmittel verwendet wird, welches NO_x -Komponenten in dem Abgas in einer oxidierenden Atmosphäre absorbiert, und außerdem eine Stufe umfasst, wonach das Abgas mit dem NO_x -Absorbtionsmittel in Kontakt gebracht wird, nachdem das Abgas den NH_3 synthetisierenden Katalysator kontaktiert hat und bevor das Abgas den NH_3 abbauenden Katalysator kontaktiert hat.
6. Verfahren gemäß Anspruch 2, wobei außerdem ein

NO_x reduzierender Katalysator verwendet wird, welcher NO_x-Komponenten in dem Abgas in einer oxidierenden Atmosphäre selektiv reduziert, und außerdem eine Stufe umfasst, wonach das Abgas mit dem NO_x-Absorbtionsmittel in Kontakt gebracht wird, nachdem das Abgas den NH₃ synthetisierenden Katalysator kontaktiert hat und bevor das Abgas den NH₃ abbauenden Katalysator kontaktiert hat.

7. Verfahren gemäß Anspruch 1 oder 2, wobei der NH₃ abbauende Katalysator eine NH₃ adsorbierende Komponente enthält, welche eine NH₃-Komponente in dem Abgas adsorbiert.
8. Verfahren gemäß Anspruch 7, wobei die NH₃ adsorbierende Komponente eine NH₃-Komponente in dem Abgas adsorbiert, wenn die Temperatur geringer ist als der vorherbestimmte Temperaturbereich.
9. Vorrichtung zum Abbau einer NH₃-Komponente, die in dem Abgas eines Verbrennungsmotors (1) enthalten ist, die folgendes umfasst:

einen NH₃ abbauenden Katalysator (7), der in einem Abgasweg (2) eines Verbrennungsmotors angeordnet ist, wobei der NH₃ abbauende Katalysator eine NH₃-Komponente in einem in den Katalysator strömenden Abgas in einer oxidierenden Atmosphäre abbaut, ohne im wesentlichen NO_x-Komponenten in der oxidierenden Atmosphäre herzustellen, wenn die Temperatur des Katalysators in dem vorherbestimmten Bereich liegt, wobei der vorherbestimmte Temperaturbereich derart definiert ist, dass bei Katalysatortemperaturen, die höher sind als der vorherbestimmte Temperaturbereich, der NH₃ abbauende Katalysator die NH₃-Komponente in dem Abgas in einer oxidierenden Atmosphäre zu NO_x-Komponenten umwandelt und derart definiert ist, dass bei Katalysatortemperaturen, die niedriger sind als der vorherbestimmte Temperaturbereich, der NH₃ abbauende Katalysator es ermöglicht, dass die NH₃-Komponente in dem Abgas in einer oxidierenden Atmosphäre durch den Katalysator tritt; eine Sauerstoffeinspeisungseinrichtung (9) zum Einspeisen von Sauerstoff in das in den NH₃ abbauenden Katalysator strömende Abgas, so dass das in den NH₃ abbauenden Katalysator strömende Abgas zu einer oxidierenden Atmosphäre wird; und eine Temperaturbeibehaltungseinrichtung zum Beibehalten der Temperatur des in den NH₃ abbauenden Katalysator strömenden Abgases in dem vorherbestimmten Temperaturbereich unabhängig von einer Änderung in der Temperatur des aus dem Verbrennungsmotor ausgesto-

ßen Abgases.

10. Vorrichtung gemäß Anspruch 9, die außerdem ein NO_x-Absorbtionsmittel (8) umfasst, welches selektiv NO_x-Komponenten in dem Abgas in einer oxidierenden Atmosphäre absorbiert und auf dem Abgasweg stromabwärts von dem NH₃ abbauenden Katalysator angeordnet ist.
11. Vorrichtung gemäß Anspruch 9, die außerdem einen NO_x reduzierenden Katalysator (8) umfasst, welcher NO_x-Komponenten in dem Abgas in einer oxidierenden Atmosphäre selektiv reduziert und auf dem Abgasweg stromabwärts von dem NH₃ abbauenden Katalysator angeordnet ist.
12. Vorrichtung gemäß Anspruch 9, die folgendes umfasst:

eine Mehrzahl von NH₃ abbauenden Katalysatoren (7), die in einem Abgasweg eines Verbrennungsmotors in einer Serienanordnung angeordnet sind, wobei jeder der NH₃ abbauenden Katalysatoren, die eine in den Katalysator strömende NH₃-Komponente in einer oxidierenden Atmosphäre abbaut, ohne im wesentlichen NO_x-Komponenten in der oxidierenden Atmosphäre herzustellen, wenn die Temperatur des Katalysators in dem vorherbestimmten Temperaturbereich liegt; die Sauerstoffeinspeisungseinrichtung (8), die Sauerstoff selektiv in das Abgas einspeist, das in die jeweiligen NH₃ abbauenden Katalysatoren strömt; die Temperaturermittlungseinrichtung, die die Temperatur der jeweiligen NH₃ abbauenden Katalysatoren ermittelt, und eine Auswahleinrichtung (30) zum Steuern der Sauerstoffeinspeisungseinrichtung auf eine Weise, dass die Sauerstoffeinspeisungseinrichtung Sauerstoff in den/die NH₃ abbauenden Katalysator(en) einspeist, dessen/deren Temperatur innerhalb des vorherbestimmten Bereichs liegt.

13. Vorrichtung gemäß Anspruch 9, die außerdem folgendes umfasst:

einen NH₃ synthetisierenden Katalysator (3), der auf einem Abgasweg des Motors stromaufwärts von dem NH₃ abbauenden Katalysator angeordnet ist, wobei der NH₃ synthetisierende Katalysator aus dem Motor ausgestoßene NO_x-Komponenten in dem Abgas in NH₃ und N₂-Komponenten umwandelt, wenn das Luft-Treibstoff- Betriebsverhältnis geringer ist als das stöchiometrische Luft-Treibstoffverhältnis; und

wobei durch den NH₃ abbauenden Katalysator (7), der auf dem Abgasweg stromabwärts von

dem NH_3 synthetisierenden Katalysator angeordnet ist, die durch den NH_3 synthetisierenden Katalysator (3) hergestellte NH_3 -Komponente adsorbiert wird, wenn das Luft-Treibstoff Betriebsverhältnis des Motors niedriger ist als das stöchiometrische Luft-Treibstoffverhältnis, und wobei der NH_3 abbauende Katalysator (7) NO_x -Komponenten in dem aus des Motors ausgestoßenem Abgas vermindert und durch den NH_3 synthetisierenden Katalysator (3) treten läßt, wenn das Luft-Treibstoff-Betriebsverhältnis des Motors höher ist als das stöchiometrische Luft-Treibstoffverhältnis, indem die NO_x -Komponenten mit der in dem NH_3 abbauenden Katalysator (7) adsorbierten NH_3 -Komponente reagieren, wobei in der Vorrichtung das Luft-Treibstoff-Betriebsverhältnis des Motors um das stöchiometrische Luft-Treibstoffverhältnis herum auf eine Weise fluktuiert, dass das durchschnittliche Luft-Treibstoff-Betriebsverhältnis des Motors höher ist als das stöchiometrische Luft-Treibstoffverhältnis.

14. Vorrichtung gemäß Anspruch 9, die außerdem folgendes umfasst:

einen NH_3 synthetisierenden Katalysator (3), der auf einem Abgasweg des Motors angeordnet ist, wobei der NH_3 synthetisierende Katalysator aus dem Motor ausgestoßene NO_x -Komponenten in dem Abgas in NH_3 und N_2 -Komponenten umwandelt, wenn das Luft-Treibstoff-Betriebsverhältnis des Motors geringer ist als das stöchiometrische Luft-Treibstoffverhältnis; ein NO_x -Absorptionsmittel (8), das auf dem Abgasweg stromabwärts von NH_3 synthetisierenden Katalysator (3) angeordnet ist, wobei das NO_x -Absorptionsmittel aus dem Motor ausgestoßene NO_x -Komponenten in dem Abgas absorbiert, wenn das Luft-Treibstoff-Betriebsverhältnis höher liegt als das stöchiometrische Luft-Treibstoffverhältnis und die absorbierten NO_x -Komponenten freisetzt, wenn das Luft-Treibstoff-Betriebsverhältnis des Motors niedriger ist als das stöchiometrische Luft-Treibstoffverhältnis; und

wobei der NH_3 abbauende Katalysator (7) auf dem Abgasweg stromabwärts von dem NO_x -Absorptionsmittel (8) angeordnet ist, wobei, wenn das Luft-Treibstoff-Betriebsverhältnis des Motors niedriger ist als das stöchiometrische Luft-Treibstoff-Verhältnis, der NH_3 abbauende Katalysator die aus dem NO_x -Absorptionsmittel freigesetzten NO_x -Komponenten reduziert, indem die NO_x -Komponenten mit der durch den NH_3 synthetisierenden Katalysator hergestellten NH_3 -Komponente reagieren, wobei in der Vorrichtung das Luft-Treibstoff-Betriebsverhältnis um das stöchiometrische Luft-

Treibstoffverhältnis herum auf eine derartige Weise fluktuiert, dass das durchschnittliche Luft-Treibstoff-Betriebsverhältnis des Motors höher ist als das stöchiometrische Luft-Treibstoffverhältnis.

15. Vorrichtung gemäß Anspruch 9, die außerdem folgendes umfasst:

einen NH_3 synthetisierenden Katalysator (3), der auf einem Abgasweg des Motors angeordnet ist, wobei der NH_3 synthetisierende Katalysator aus dem Motor ausgestoßene NO_x -Komponenten in dem Abgas in NH_3 - und N_2 -Komponenten umwandelt, wenn das Luft-Treibstoff-Betriebsverhältnis des Motors niedriger ist als das stöchiometrische Luft-Treibstoffverhältnis;

wobei der NH_3 abbauende Katalysator (7) auf dem Abgasweg stromabwärts von dem NH_3 synthetisierenden Katalysator angeordnet ist, wobei der NH_3 abbauende Katalysator aus dem Motor ausgestoßene NO_x -Komponenten in dem Abgas absorbiert und durch den NH_3 synthetisierenden Katalysator (3) hindurchtreten läßt, wenn das Luft-Treibstoff-Betriebsverhältnis des Motors höher ist als das stöchiometrische Luft-Treibstoffverhältnis, wobei in der Vorrichtung das Luft-Treibstoff-Betriebsverhältnis des Motors um das stöchiometrische Luft-Treibstoffverhältnis herum auf eine derartige Weise fluktuiert, dass das durchschnittliche Luft-Treibstoff-Betriebsverhältnis höher ist als das stöchiometrische Luft-Treibstoffverhältnis.

16. Vorrichtung gemäß Anspruch 9 oder 12, wobei der NH_3 abbauende Katalysator eine NH_3 adsorbierende Komponente enthält, welche eine NH_3 -Komponente in dem Abgas adsorbiert.

17. Vorrichtung gemäß Anspruch 16, wobei die NH_3 adsorbierende Komponente eine NH_3 -Komponente in dem Abgas adsorbiert, wenn die Temperatur niedriger ist als der vorherbestimmte Temperaturbereich.

18. Vorrichtung gemäß Anspruch 16, wobei die NH_3 adsorbierende Komponente eine saure anorganische Substanz umfasst.

19. Vorrichtung gemäß Anspruch 16, wobei die NH_3 adsorbierende Komponente wenigstens eine Substanz umfasst, die aus Zeolith, Siliciumdioxid (SiO_2), Titandioxid (TiO_2), Siliciumdioxid-Aluminiumoxid ($\text{SiO}_2\text{-Al}_2\text{O}_3$), Kupfer (Cu), Cobalt (Co), Nickel (Ni) und Eisen (Fe) ausgewählt ist.

Revendications

1. Un procédé pour décomposer un composé NH_3 dans des gaz d'échappement de combustion en

- mettant en contact des gaz d'échappement contenant un composé NH_3 dans une atmosphère oxydante à une température dans une plage prédéterminée avec un catalyseur de décomposition NH_3 qui décompose les composés NH_3 des gaz d'échappement en une atmosphère oxydante sensiblement sans produire des composés NO_x dans ladite atmosphère oxydante lorsque la température du catalyseur est dans ladite plage de températures prédéterminées, dans lequel ladite plage de températures prédéterminées est définie de sorte qu'à des températures de catalyse supérieures à ladite plage de températures prédéterminées, ledit catalyseur de décomposition de NH_3 convertit les composés NH_3 des gaz d'échappement dans une atmosphère oxydante en composés NO_x et de sorte qu'à des températures de catalyseur inférieures à ladite plage de températures prédéterminées, ledit catalyseur de décomposition de NH_3 permet au composé NH_3 des gaz d'échappement dans une atmosphère oxydante de passer à travers le catalyseur.
2. Procédé selon la revendication 1, comprenant en outre avant ladite étape de mise en contact desdits gaz d'échappement de combustion dans une atmosphère oxydante dans ladite plage de températures prédéterminées avec ledit catalyseur de décomposition de NH_3 :
- la mise en contact de gaz d'échappement d'un moteur à combustion interne dans une atmosphère réductrice avec un catalyseur de synthèse de NH_3 qui convertit des composés NO_x des gaz d'échappement dans une atmosphère réductrice en un composé NH_3 ; et
 - l'ajustement des conditions des gaz d'échappement après qu'ils ont été mis en contact avec le catalyseur de synthèse de NH_3 de sorte que les gaz d'échappement soient dans une atmosphère oxydante et à l'intérieur de ladite plage de températures prédéterminées.
3. Le procédé selon la revendication 2, dans lequel ledit moteur à combustion interne est mis en fonctionnement avec un rapport air-carburant proche du rapport air-carburant stoechiométrique et dans lequel un catalyseur trois voies oxydant et réducteur est utilisé en tant que ledit catalyseur de synthèse de NH_3 .
4. Le procédé selon la revendication 2, dans lequel ledit moteur à combustion interne est mis en fonctionnement avec un rapport air-carburant inférieur au rapport air-carburant stoechiométrique, et un catalyseur oxydant et de réduction trois voies est utilisé en tant que ledit catalyseur de synthèse de NH_3 .
5. Le procédé selon la revendication 2, comprenant en outre un absorbeur de NO_x qui absorbe les composés NO_x des gaz d'échappement dans une atmosphère oxydante, et comprenant en outre une étape de mise en contact desdits gaz d'échappement avec ledit absorbeur de NO_x après que les gaz d'échappement aient été mis en contact avec le catalyseur de synthèse de NH_3 et avant que les gaz d'échappement soient mis en contact avec le catalyseur de décomposition de NH_3 .
6. Le procédé selon la revendication 2, comprenant en outre l'utilisation d'un catalyseur de réduction de NO_x qui réduit sélectivement les composés NO_x dans les gaz d'échappement dans une atmosphère oxydante, et comprenant en outre une étape de mise en contact desdits gaz d'échappement avec le catalyseur de réduction de NO_x après que les gaz d'échappement ont été mis en contact avec le catalyseur de synthèse de NH_3 et avant que les gaz d'échappement soient mis en contact avec le catalyseur de décomposition de NH_3 .
7. Le procédé selon la revendication 1 ou 2, dans lequel ledit catalyseur de décomposition contient un composant d'absorption de NH_3 qui absorbe un composé NH_3 de gaz d'échappement.
8. Le procédé de la revendication 7, dans lequel ledit composant d'absorption de NH_3 adsorbe un composé NH_3 dans les gaz d'échappement lorsque la température est inférieure à ladite plage de températures prédéterminées.
9. Un dispositif pour décomposer un composé NH_3 contenu dans les gaz d'échappement d'un moteur à combustion (1) comprenant :
- un catalyseur de décomposition de NH_3 (7) placé dans un passage de gaz d'échappement (2) d'un moteur à combustion interne, ledit catalyseur de décomposition de NH_3 décomposant un composé NH_3 des gaz d'échappement s'écoulant vers le catalyseur dans une atmosphère oxydante sensiblement sans produire de composés NO_x dans ladite atmosphère oxydante lorsque la température du catalyseur est dans une plage de températures prédéterminées, dans lequel ladite plage de températures prédéterminées est définie de sorte qu'à des températures de catalyseur supérieures à ladite plage de températures prédéterminées, ledit catalyseur de décomposition de NH_3 convertit le composé NH_3 de gaz d'échappement dans une atmosphère oxydante en composés NO_x et de sorte qu'à des températures de catalyseur inférieures à ladite plage de températures prédéterminées, ledit catalyseur de décomposition

de NH_3 permet aux composés NH_3 des gaz d'échappement dans une atmosphère oxydante de passer à travers le catalyseur ;

- des moyens de fourniture d'oxygène (9) pour fournir de l'oxygène aux gaz d'échappement s'écoulant vers ledit catalyseur de décomposition de NH_3 de sorte que le gaz d'échappement s'écoulant vers ledit catalyseur de décomposition de NH_3 devienne une atmosphère oxydante ; et
- des moyens de maintien de température pour maintenir la température des gaz d'échappement s'écoulant vers ledit catalyseur de décomposition de NH_3 à l'intérieur de ladite plage de températures prédéterminées sans tenir compte d'une variation de températures du gaz d'échappement expulsées par le moteur à combustion interne.

10. Le dispositif de la revendication 9, comprenant en outre un absorbeur de NO_x (8) qui absorbent des composés NO_x des gaz d'échappement dans une atmosphère oxydante et est disposé sur un passage de gaz d'échappement en aval dudit catalyseur de décomposition de NH_3 .

11. Le dispositif de la revendication 9, comprenant en outre un catalyseur de réduction de NO_x (8) qui réduit sélectivement les composés NO_x dans les gaz d'échappement dans une atmosphère oxydante et est disposé dans le passage de gaz d'échappement en aval dudit catalyseur de décomposition de NH_3 .

12. Le dispositif de la revendication 9, comprenant

- une pluralité de catalyseurs de décomposition de NH_3 (7) placé selon un agencement en série dans un passage de gaz d'échappement (2) d'un moteur à combustion interne, chacun desdits catalyseurs de décomposition de NH_3 décomposant un composé NH_3 du gaz d'échappement s'écoulant vers le catalyseur dans une atmosphère oxydante sensiblement sans produire de composés NO_x dans ladite atmosphère oxydante lorsque la température du catalyseur est dans ladite plage de températures prédéterminées ;
- lesdits moyens de fourniture d'oxygène (8) fournissant sélectivement de l'oxygène aux gaz d'échappement s'écoulant vers les catalyseurs de décomposition de NH_3 respectifs ;
- lesdits moyens de sélection de température détectant la température des catalyseurs de décomposition de NH_3 respectifs ; et
- les moyens de sélection (30) pour contrôler lesdits moyens de fourniture d'oxygène de telle façon que les moyens de fourniture d'oxygène fournissent de l'oxygène aux gaz d'échappe-

ment s'écoulant vers le ou les catalyseurs de décomposition de NH_3 dont la température est dans ladite plage de températures prédéterminées.

13. Le dispositif de la revendication 9, comprenant en outre :

- un catalyseur de synthèse de NH_3 (3) placé dans un passage de gaz d'échappement du moteur à combustion à l'amont dudit catalyseur de décomposition de NH_3 , dans lequel ledit catalyseur de synthèse de NH_3 convertit les composés NO_x dans les gaz d'échappement déchargés depuis le moteur à combustion en des composés NH_3 et N_2 lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique ;
- par ledit catalyseur de décomposition de NH_3 (7) placé dans le passage de gaz d'échappement à l'aval du catalyseur de synthèse de NH_3 , le composé NH_3 produit par le catalyseur de synthèse de NH_3 (3) est adsorbé lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique et dans lequel ledit catalyseur de décomposition de NH_3 (7) réduit les composés NO_x des gaz d'échappement déchargés par le moteur à combustion et passent à travers le catalyseur de synthèse de NH_3 (3) lorsque le rapport air-carburant de fonctionnement du moteur à combustion est supérieur au rapport air-carburant stoechiométrique en faisant réagir les composés NO_x avec le composé NH_3 adsorbé dans le catalyseur de décomposition de NH_3 (7), dans lequel dans ledit dispositif le rapport air-carburant de fonctionnement du moteur à combustion fluctue à proximité du rapport air-carburant stoechiométrique de sorte que le rapport air-carburant de fonctionnement moyen du moteur à combustion est supérieur au rapport air-carburant stoechiométrique.

14. Le dispositif de la revendication 9, comprenant en outre :

- un catalyseur de synthèse de NH_3 (3) disposé dans un passage de gaz d'échappement d'un moteur à combustion, dans lequel ledit catalyseur de synthèse de NH_3 convertit les composés NO_x des gaz d'échappement expulsés par le moteur à combustion en composés NH_3 et N_2 lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique ;
- un absorbeur NO_x (8) placé dans le passage

de gaz d'échappement à l'aval du catalyseur de synthèse de NH_3 (3) dans lequel ledit absorbeur de NO_x absorbe les composés NO_x dans les gaz d'échappement expulsés par le moteur à combustion et passe à travers le catalyseur de synthèse de NH_3 lorsque le rapport air-carburant de fonctionnement du moteur à combustion est supérieur au rapport air-carburant stoechiométrique et libère les composés NO_x absorbés lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique ;

- ledit catalyseur de décomposition de NH_3 (7) est disposé dans le passage de gaz d'échappement en aval de l'absorbeur de NO_x (8), dans lequel, lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique, ledit catalyseur de décomposition de NH_3 réduit les composés NO_x libérés par l'absorbeur de NO_x en faisant réagir lesdits composés de NO_x avec le composé NH_3 produit par le catalyseur de synthèse de NH_3 , dans lequel dans ledit dispositif le rapport air-carburant de fonctionnement du moteur à combustion fluctue autour du rapport air-carburant stoechiométrique de façon que le rapport air-carburant de fonctionnement moyen du moteur à combustion soit supérieur au rapport air-carburant stoechiométrique.

15. Un dispositif selon la revendication 9, comprenant en outre :

- un catalyseur de synthèse de NH_3 (3) placé dans un passage de gaz d'échappement du moteur à combustion, dans lequel ledit catalyseur de synthèse de NH_3 convertit des composés NO_x des gaz d'échappement déchargés depuis le moteur à combustion en composés NH_3 et N_2 lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique ;
- ledit catalyseur de décomposition de NH_3 (7) est disposé dans le passage de gaz d'échappement en aval du catalyseur de synthèse de NH_3 , dans lequel ledit catalyseur de décomposition de NH_3 adsorbe les composés NO_x des gaz d'échappement expulsés depuis le moteur à combustion et passe à travers le catalyseur de synthèse de NH_3 (3) lorsque le rapport air-carburant de fonctionnement du moteur à combustion est supérieur au rapport air-carburant stoechiométrique dans lequel ledit catalyseur de décomposition de NH_3 (7) réduit les composés NO_x absorbés en faisant réagir lesdits com-

posés NO_x avec le composé NH_3 produit par le catalyseur de synthèse de NH_3 (3) lorsque le rapport air-carburant de fonctionnement du moteur à combustion est inférieur au rapport air-carburant stoechiométrique, dans lequel, dans ledit dispositif le rapport air-carburant de fonctionnement du moteur à combustion fluctue autour du rapport air-carburant stoechiométrique de telle façon que le rapport air-carburant de fonctionnement moyen du moteur à combustion soit supérieur au rapport air-carburant stoechiométrique.

- 16. Un dispositif selon la revendication 9 ou 12, dans lequel ledit catalyseur de décomposition de NH_3 contient un composant d'adsorption de NH_3 qui adsorbe un composé NH_3 des gaz d'échappement.
- 17. Un dispositif selon la revendication 16, dans lequel ledit composant d'adsorption de NH_3 adsorbe un composé NH_3 des gaz d'échappement lorsque la température est inférieure à ladite plage de températures prédéterminées.
- 18. Un dispositif selon la revendication 16, dans lequel ledit composant d'adsorption de NH_3 comprend une substance inorganique acide.
- 19. Un dispositif selon la revendication 16, dans lequel ledit composant d'adsorption de NH_3 comprend au moins une substance choisie parmi la zéolite, la silice (SiO_2), le titane (TiO_2), le silica d'alumine ($\text{SiO}_2\text{-Al}_2\text{O}_3$), le cuivre (Cu), le cobalt (Co), le nickel (Ni) et le fer (Fe).

Fig.1

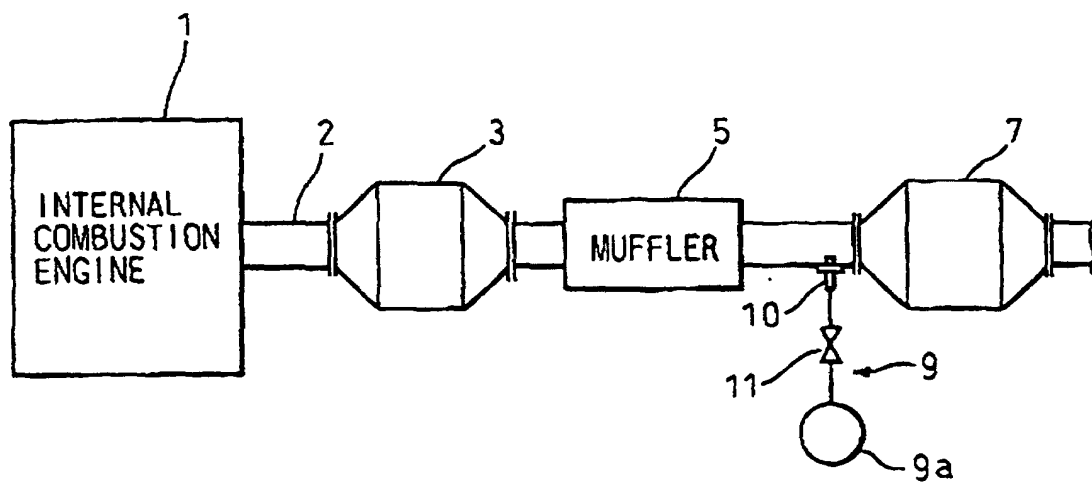


Fig. 2

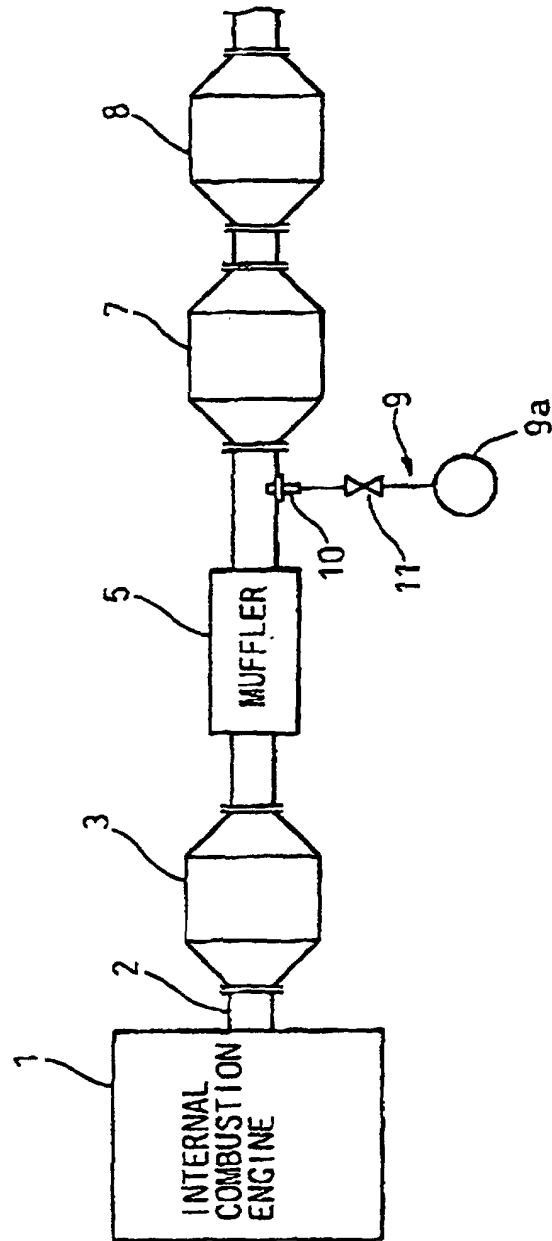


Fig.3

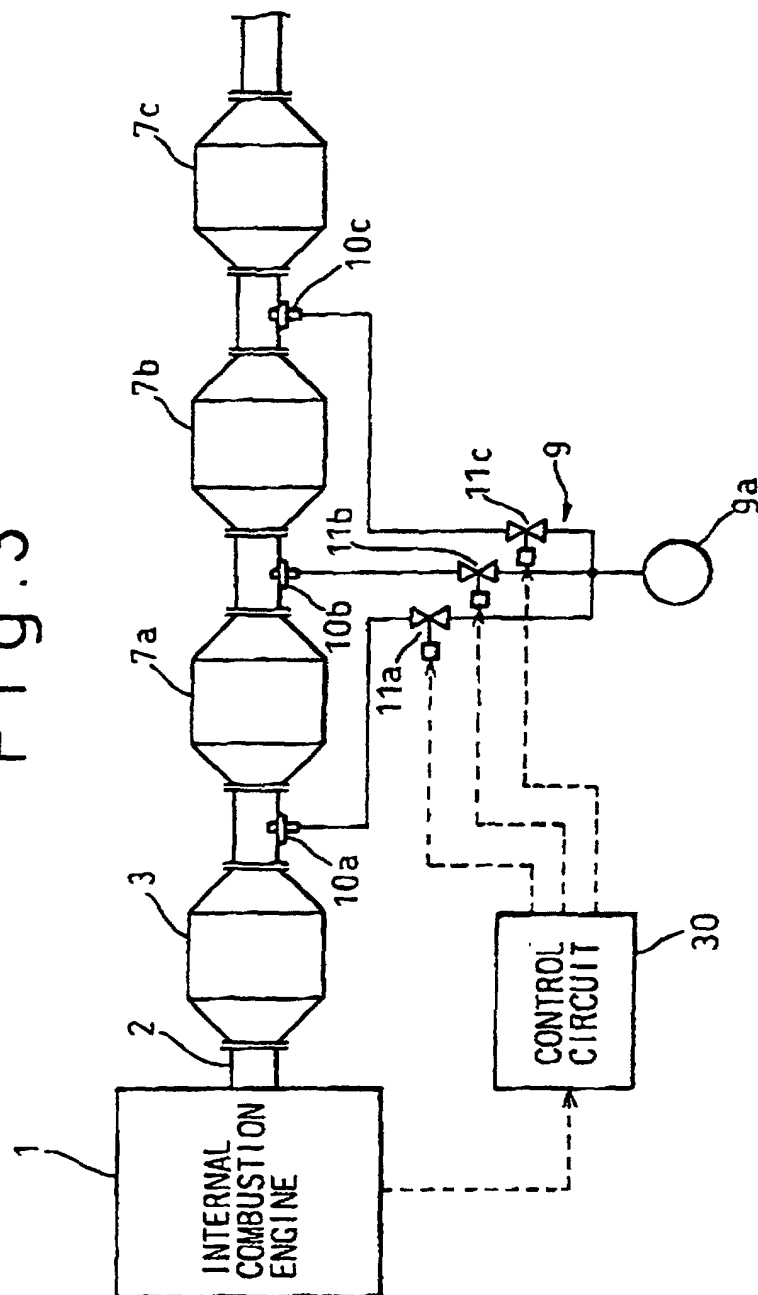


Fig. 4

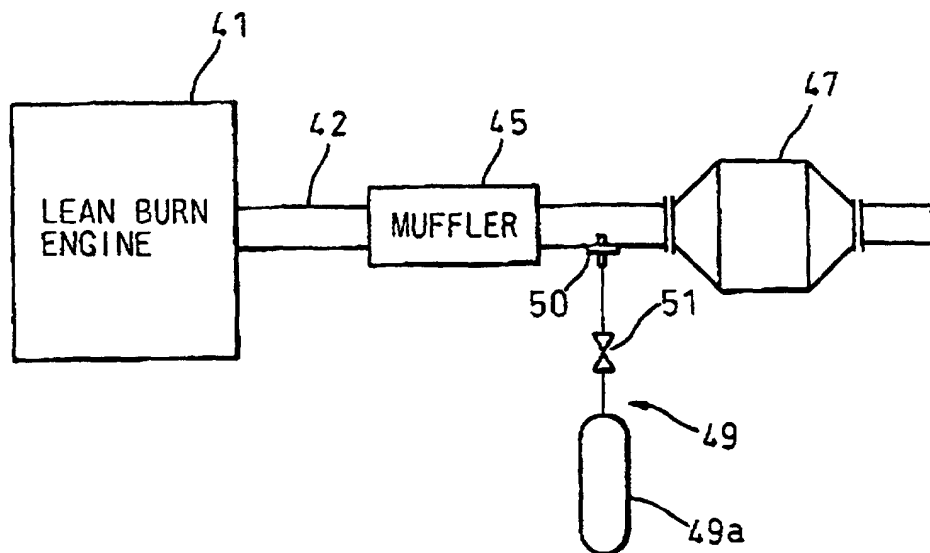


Fig. 5

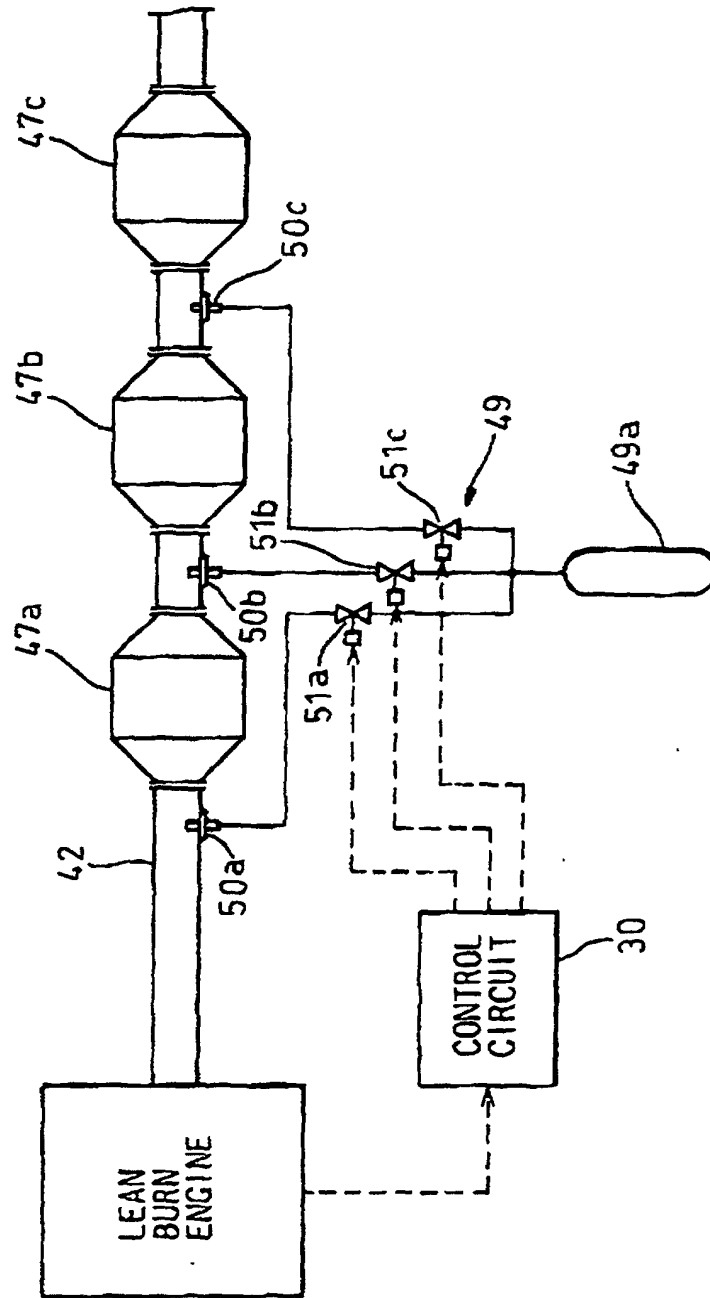


Fig. 6

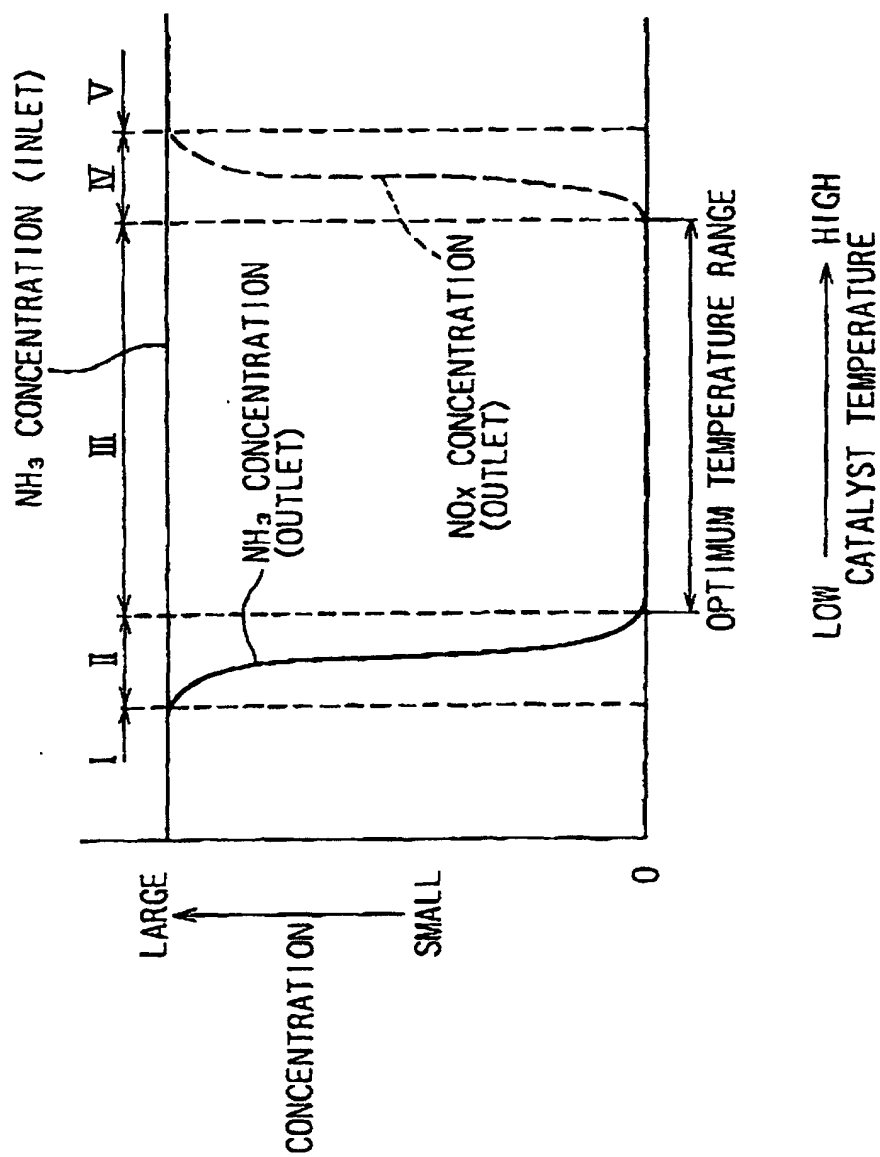


Fig. 7

